# Canada - Department of Agriculture



# REPORT

of the

# SCIENCE SERVICE

FOR THE YEAR ENDED MARCH 31

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REPORT

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SCIENCE SERVICE

DEPARTMENT OF AGRICULTURE

Ottawa, Canada

FOR THE

YEAR ENDED MARCH 31, 1949

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## ERRATUM

In the Report of the Science Service, Dominion Department of Agriculture, for the year ended March 31, 1948, p. 66, paragraph 4, the sentence now reading "*Gibberella cyanogena* (*F. sambucinum*) proved to be bisexual and self-fertile" should read "*Gibberella cyanogena* (*F. sambucinum*) proved to be bisexual and self-sterile."

## SCIENCE SERVICE

The Science Service of the Dominion Department of Agriculture was established as a separate unit in 1938 when a general reorganization of the Department took place. Five existing divisions were combined at that time. The Plant Protection Division was added to the Service in 1942.

Science Service includes the research Divisions of Animal Pathology, Bacteriology and Dairy Research, Botany and Plant Pathology, Chemistry and Entomology, and the Division of Plant Protection. Centralized accounting and personnel services for these six units are maintained in the Administrative Division.

This report does not attempt to present in detail the results of investigations on the many projects now under way. Detailed reports have been published in scientific journals, and where further information is desired by research workers on particular projects, inquiries should be directed to the laboratories concerned. Publications giving detailed information for the use of farmers are available from the Dominion Department of Agriculture, Ottawa.

The work of Science Service is directed toward the solution of practical problems of agriculture through scientific investigation. The Service is responsible for the maintenance and development of the National Collection of Insects, the Dominion Arboretum, and an economic herbarium. It deals with problems relating to the ravages of insect pests and diseases affecting plants and animals, the deterioration of plant and animal products through the invasion of fungi and bacteria, the nutritional requirements of plants and animals, and the chemistry and microbiology of soils, foods and dairy products. It carries out chemical and biological determinations required in the administration of various Dominion Acts and Regulations, and administers the Destructive Insect and Pest Act, including the inspection of imported and exported plants and plant products and the establishment of quarantine and control measures for introduced pests and diseases. The work in the various laboratories of the Science Service is co-ordinated with agricultural research undertaken by the Experimental Farms Service and other units of the Department, and with certain special research projects undertaken by the National Research Council and by universities and colleges of agriculture.

Some of the more important activities of the Divisions of Science Service during the past year are listed hereunder; more detailed statements are given in the Divisional reports which follow.

### HIGHLIGHTS OF THE YEAR'S WORK

#### Animal Pathology

Further studies with penicillin in mastitis control have emphasized its practical value.

The concurrent use of spreading factors and killed *Brucella abortus* has not proved a successful means of producing immunity to brucellosis.

Many problems of pullorum disease of chickens have been solved and intensive work is under way relating to pullorum disease of turkeys.

It has been found that the parasite which acts as an intermediate host to the causative agent of enterohepatitis of turkeys is present in both Eastern and Western Canada but, in general, the parasite in Western Canada does not carry

the infection. This explains the difficulties experienced by poultry raisers in the East in raising turkeys in close proximity to chickens which are the natural host to the parasite.

A study of many strains of tubercle bacilli appears to indicate that some have a more restricted antigenic coverage and tuberculin produced from these is likely to give fewer reactions in animals sensitized only with related organisms.

A new test has been evolved which makes possible the examination of blood from chickens or other animals that contain inhibiting properties by means of a modification of the complement fixation test.

Newcastle disease has been demonstrated in Canada and a vaccine is being produced which gives considerable protection.

During the year 174,358 samples of blood from animals suspected of being infected with brucellosis were examined, while 2,884,923 doses of biologics were produced and distributed.

Thirty papers relating to research studies were published.

## Bacteriology and Dairy Research

Penicillin in the milk from herds treated for mastitis may affect the results with the methylene blue test for milk quality.

The extensive use of penicillin for the treatment of bovine mastitis may interfere with normal acid development in the manufacture of cheddar cheese.

Lipolytic bacteria contaminating milk are considered to be one of the main causes of unclean and rancid flavour defects in cheddar cheese.

A routine test for detecting numbers of lipolytic bacteria in cheese factory milk supplies has been developed.

A new type of bacterial spoilage in Canadian process cheese was found to be due to *Clostridium sporogenes*.

Bacteria counts from frozen eggs showed a marked improvement over those for the previous year.

Used strawberry hallocks are a serious potential source of mould contamination of berries.

Bacteria possessing the enzyme tyrosinase may, in the presence of iron, cause black discoloration of canned beets.

The correction of manganese deficiency in soil by the use of cyanogas as a soil fumigant was correlated with a lowered incidence of cellulose-decomposing bacteria and a higher level of replaceable manganese.

Sodium sulphathiazole, fed to colonies of bees at the rate of 0.5 gm. per gallon sugar syrup inoculated with spores of *Bacillus larvae*, effectively prevented infection of the larvae. The use of the drug also resulted in the cleaning up of colonies infected with American foulbrood.

Bee larvae were found to be susceptible to American foulbrood only during the first 48 to 54 hours.

Results of tests for germicidal effectiveness of hypochlorites of high and low alkalinity are markedly affected by the thickness and degree of dehydration of the milk film employed in the testing procedure.

## Botany and Plant Pathology

In co-operation with the Defence Research Board, the work on systematic botany in northern Canada in the summer of 1948 greatly advanced the knowledge of the flora of that area.

The botanical herbarium continued to expand during the year with the addition of 14,017 specimens, bringing the total of mounted material to slightly over 100,000 sheets.

Applications for the registration of herbicides totalled 131 as compared with 91 in 1947 and 56 in 1946. Various formulations of 2,4-D accounted for 117 of the year's applications.

Certain oil fractions are being used for the control of weeds in fields of carrots and parsnips. By means of the infra-red absorption apparatus it was shown that the oils disrupted the normal photosynthetic activity, respiration, and transpiration of mustard and of the carrot and parsnip. The two crop plants recovered their normal activities in a short time, but the mustard showed no recovery.

The co-operative survey for the presence of the Dutch elm disease showed that there was considerable intensification of the disease in the eastern part of the infected area south of the St. Lawrence River. The infected area now comprises 36 counties. A single infected tree with typical symptoms was found in the City of Ottawa.

The investigations on the die-back disease of yellow and white birches in the Maritime Provinces have shown that the appearance of the early stages of the disease is not dependent on an attack of the bronze birch borer. Excavations of root systems indicate that the death of a portion of the feeding rootlets precedes twig mortality and that the percentage of dead rootlets increases with the degree of crown injury.

A forest pathological laboratory for the study of tree diseases in the Prairie Provinces has been established at Saskatoon, where temporary accommodation is being provided by the National Research Council.

To facilitate the development of varieties of cereals possessing resistance to the prevailing races of smuts, a survey was made of the races of cereal smuts present in Canada and a large number of varieties of cereals was tested for resistance to these races. Among the hard red spring wheats, Redman is the most highly resistant to bunt and Thatcher to loose smut. Garry and Fortune oats proved to be resistant to the oat smuts and all of the commonly grown barley varieties are susceptible to one or more of the barley smuts.

In Western Canada, numerous tests have shown that several of the new hard red spring wheat hybrids are more resistant to root-rot than the commonly grown varieties, although less resistant than McMurachy's Selection. None of the new durum wheat hybrids tested was superior in root-rot resistance to the varieties now being grown.

More sunflower rust occurred in Manitoba in 1948 than in the preceding years. The hybrid variety, Advance, was not appreciably affected. The female parent of this variety, however, is highly susceptible and in crossing blocks the yield of seed was seriously reduced.

A disease of strawberry plants, caused by the fungus *Dendrophoma obscurans*, hitherto unreported in Canada, has been found in several areas in Ontario. It apparently causes as much injury as the leaf spot and leaf scorch.

The radioactive isotope of phosphorus, $P^{32}$, tends to migrate faster into potato plants infected with the leaf-roll virus and slower into those infected with rugose mosaic than it does in plants of the same variety free from these viruses. Aphids fed on these plants become radioactive and remain so for 7 to 10 days following their removal from the plants.

In the use of various herbicides for the killing of potato tops as a means of preventing late blight tuber rot and the dissemination of viruses late in the season, it was found that the more rapidly the tops are killed the more internal discoloration occurs in the tubers.

Promising results are being obtained in the use of serological methods for the detection within the seed of the bacteria causing the blights of beans. This work is being done co-operatively with the Division of Animal Pathology.

The use of Arasan for the control of the blackroot disease of sugar beets, which was so successful in greenhouse tests, has proved to be equally successful under field conditions. Not only were the stands of seedlings increased, but in two of the three fields the yields were significantly greater.

## Chemistry

Factors affecting the nutritive value of rations for cattle, sheep and swine, have been studied.

The stability of different compounds of iodine in block salt was determined.

Experiments were carried out on the toxicity to livestock of mineral salts.

Continued investigations of the stable isotope of nitrogen, $N^{15}$, have indicated its value in studying livestock nutritional problems.

It has been demonstrated by the use of radioactive calcium that the role of vitamin D lies in preventing the solution of calcium from the bone and only indirectly in increasing the absorption from the gut.

The use of radioactive phosphorus has indicated that dietary calcium may improve the retention of phosphorus in the chick.

An enzyme has been found in the liver which is important in the metabolism of carotene.

The chemical determination of thyroxine iodine in iodinated proteins cannot be used as an index of biological activity.

Since the inauguration of grading there has been a marked improvement in the quality of milk powders.

The development of an improved polarographic method for zinc is expediting the study of plant requirements.

Parathion as a surface residue on plants or fruit disappeared rapidly.

Moderate application to flax of 2,4-D in the amine or ester form resulted in reduced oil content and increased protein in the seeds.

Nova Scotia apples, during the 1947 and 1948 seasons, showed a tendency toward a higher acidity.

Carrot roots containing 43 p.p.m. boron were more resistant to bacterial blight (*Xanthomonas carotae*) than those containing 19 p.p.m.

Insecticide deposits were more uniform with hand spraying than with a commercial high speed sprayer.

*Phytophthora parasitica* showed promise as a test organism for the estimation of thiamin.

Colloidal fractions separated from some Quebec and Nova Scotia soils represented 10 to 27 per cent of the soil but contained 60 to 75 per cent of the total soil phosphorus.

A lignin-like material separated from soil organic matter exhibited chemical properties which differed in many respects from those of wood lignin.

With a group of Ontario soils when the phosphorus content of the crop on a 4-0-10 treatment was low, relatively high responses were obtained when phosphorus was applied in a 4-10-10 fertilizer. On the other hand, where the crop phosphorus content was high, relatively low responses to applied phosphorus were obtained.

A deficiency of the nutrient boron was directly reflected in the boron content of peas.

The sand fraction of a Saskatchewan soil contained relatively greater amounts of zircon, opaque, epidote and orthoclase than did some Ontario soils and also contained considerable quantities of chlorite and biotite which were absent in the Ontario soils.

Definite improvements were effected in methods for the determination of phosphorus in the presence of arsenic and of nitrates in coloured soil extracts.

## Entomology

The extended use of chlordane or toxaphene as a spray, or as the poison in poison bait, proved that these materials are more effective in grasshopper control than the arsenicals and fluosilicates.

For some years it has been known that the wheat-stem sawfly could survive a year of severe drought by remaining inactive in the infested stubble. Biological studies have proved that this prolonged inactivity does not affect the survival of the larvae, the eventual emergence of adults, or their reproductive capacity.

Excellent and rapid control of wireworms has been secured by using benzene hexachloride or ethylene dibromide, and fair control has been secured with chlordane. DDT, which at first appeared to give no control, has almost eliminated wireworms within three years after being worked into the soil.

Some hybrid corn varieties have shown a marked resistance to the European corn borer, and further investigations are being carried on at the Entomological Laboratory at Chatham, Ontario, in co-operation with the staff of the Experimental Station at Harrow.

The unprecedented outbreak of the green peach aphid as a pest of tobacco in southwestern Ontario threatened to destroy a great portion of the crop. Emergency control measures reduced crop losses.

Chlordane, in dust or spray form, gave promising results in the control of the following vegetable insects: carrot rust fly, onion maggot, turnip maggot, and grasshoppers.

In studies of residues, the amount of DDT on celery treated with 3 per cent dust was well below the tolerance, and tubers from a potato field that was sprayed at weekly intervals through the summer with parathion in emulsion form showed no trace of the chemical.

Rhothane was the most effective insecticide used against the corn earworm in New Brunswick, being superior to derris, DDT, and ryania.

Almost complete control of potato aphids resulted from the use of DDT emulsion spray (1½ pints 25 per cent emulsion in 100 gallons) or a 2 per cent parathion dust in field tests in New Brunswick.

One of the outstanding achievements in orchard pest control has been the development of a sprayer for the application of insecticides and fungicides in which a concentrated spray mixture is atomized and discharged into a high-speed air blast. This machine should greatly reduce the labour and consequently the cost of fruit production.

The fact that sprays applied for the control of some particular orchard pest may actually promote outbreaks of others by destruction of their natural enemies was given increased attention. Such an effect of DDT has been generally recognized, but studies carried on by the Fruit Insect Unit showed that other spray chemicals, particularly sulphur, may act in a similar if more obscure manner.

Large-scale field trials of parathion in 1948 confirmed the great effectiveness of this new insecticide, and it will undoubtedly find a wide range of use in insect control.

A new type of virus disease, known as a "capsule virus" to distinguish it from polyhedral diseases, was discovered in the Vosges Mountains in France. It attacks a species of budworm closely allied to the North American spruce budworm. A supply of this organism, in a highly purified state, has been imported for the purpose of testing its pathogenicity on the Canadian budworm. Preliminary experiments indicate that there is some likelihood of success.

It has been positively established that two viruses, one of the polyhedral type and the other of the capsule type, occur in populations of the native spruce budworm. Both types have been isolated and purified and will be used for artificial inoculation in centres of heavy infestation.

Biological, morphological, and cytogenic evidence has been discovered for the specific separation of the bronze birch borer from the species of *Agrilus* attacking poplar.

Air temperatures recorded on a modified thermograph with the bimetal painted with a flat black have been found accurate enough for all practical purposes in estimating the temperatures of buds, shoots, and insect tunnels under forest conditions.

The virus disease of the European spruce sawfly has been successfully established in Newfoundland. In 1948, large numbers of diseased larvae were collected in Humber, St. Barbe, and Grand Falls districts, where the first introductions were made. During the past year, additional disease material was shipped to Indian Pond and Green Bay, where new centres of infestation are developing.

An extensive reconnaissance of biting flies and a general survey of insects of the Canadian Arctic was organized in 1948. Eight parties were equipped and located at as many widely distributed stations, and collected approximately 100,000 insects, adding substantially to the knowledge of the distribution and biology of the biting flies and their importance in the settlement and the economic exploitation of the Canadian Arctic.

Parasites from Europe, as well as from British Columbia, were released in Eastern Canada to aid in control of the spruce budworm.

An artificial food medium was developed for propagation of an important parasite of the spruce budworm obtained in British Columbia.

A European parasite of the pea moth has been successfully established in Quebec, Nova Scotia, and Prince Edward Island.

The parasite *Allotropa utilis* Mues. was successfully established on the apple mealybug on Vancouver Island, British Columbia.

In an area in central Ontario it is now almost impossible to collect the larch casebearer within a radius of forty miles from the original liberation point of parasites introduced from Europe, as the parasites have become so abundant and effective.

An organism which causes a bacterial disease of codling moth was isolated, and a satisfactory method for production and field dissemination was developed and tested.

Virtually complete clearance of a large river, the South Saskatchewan, of larvae of the cattle-infesting black fly, *Simulium arcticum* Mall., for a proved distance of 17 miles and a probable distance of 90 miles was obtained by the application of sufficient DDT in an oil solution from an aircraft to give a calculated concentration of 0.13 parts DDT per million parts of water for a period of 36 minutes at the point of application.

At Churchill, parathion applied as a water suspension was effective against black fly larvae at a dosage of 1:5,000,000 for 15 minutes. Oil solutions of gamma-BHC in dosages ranging from 1:2,000,000 to 1:8,000,000 for the same exposure period completely rid streams of the larvae. Laboratory tests indicated

that both chemicals may have value as ovicides when used at concentrations of 1:2,000,000 or higher for 15 minutes. Tests showed that DDT, gamma-BHC, and parathion are not harmful to fish when used in the low dilutions required to control black fly larvae.

Experiments at Churchill, Man., to determine the relative effectiveness against *Aedes* mosquitoes of pre-thaw (prehatching) applications of several insecticides showed that DDT, TDE (DDD), and heptachlor were about equally effective, and all were superior to methoxychlor. A high degree of control was obtained from a dosage of 0.25 pound per acre. Aeroplane prehatching applications of DDT to snow and ice on the breeding places may be used for controlling northern species of *Aedes*. Parathion as a conventionally-used larvicide in wettable powder gave a high degree of control of *Aedes* larvae at 0.01 and 0.05 pound per acre.

The treatment of cotton sacks with piperonyl butoxide-pyrethrum mixture holds promise of being a cheap and effective method of preventing an insect attack upon commodities in this type of container.

Spraying cattle with benzene hexachloride at the rate of 4 ounces of 50 per cent gamma isomer to 1 gallon of water was found to keep cattle free of the paralysis tick for as long as 3 weeks. Pure gamma isomer of benzene hexachloride, when given by mouth to rabbits, destroyed all of the paralysis ticks feeding on them.

The warble fly control program in the Prairie Provinces continued to show very encouraging results. In some areas where treatment has been going on for several years, the average number of grubs per animal has dropped from 40 to less than 1.

## Plant Protection

Importations of 56,337,552 plant units, comprising 25,405,370 plants and 30,932,182 bulbs were inspected on arrival for insects and diseases.

Exports of 352,537 plants, 7,816,286 bulbs, 10,219 pounds of tree and miscellaneous seeds were inspected and certified before shipment to 35 countries. Exports of plant products, certified as a requirement of the importing countries, 28 in number, consisted of: 6,895,015 pounds of table potatoes, 297,035 pounds of field crop seeds, 160 ears of seed corn, 1,212 pounds of pears, 50,000 pounds of frozen fruit, 72,087 pounds of vegetables and 29,931 Christmas trees.

Imports of plant products, involving 1,332,319 containers, were examined for infested or infected material.

The examination of passengers' baggage for plant material was carried out in co-operation with Customs officers, principally at ocean ports. Special arrangements were made to have inspectors of the Division located at important Canada-United States border points during the busy tourist season.

Interceptions were made on imported plants and plant products on 1,162 occasions.

The inspection of cargo vessels at ocean ports, previous to loading grain and cereal products for export, was extended during the year and 1,126 vessels were examined and 165 of these required fumigation or cleaning.

Large quantities of insect-infested broom corn and peanuts were successfully fumigated in box cars, under the supervision of Division of Plant Protection officers before delivery to importers and a variety of infested and infected commodities were treated at the Divisional Fumigation and Research Laboratory in Montreal, where investigational and experimental work is being continuously conducted on various projects.

The main field projects consisted of an extensive survey for the Dutch elm disease in Quebec and Ontario, including the supervision of the removal of infected trees in both provinces, the disease being located in Ontario during 1948; Japanese beetle trapping in three provinces to determine the intensity and spread of outbreaks; the Oriental fruit moth survey in British Columbia; and gypsy moth trapping in New Brunswick. Other field activities carried on with the co-operation of Dominion and Provincial agencies were apple maggot control and surveys in Ontario, Quebec, New Brunswick and Nova Scotia, sugar beet nematode survey in Ontario and the grader inspection of fruit, for scale insects, in British Columbia.

The acreage of potatoes entered for certification throughout Canada was 70,561 representing an increase of nearly 1,100 acres over 1947. Slightly over 80 per cent of this acreage passed field inspections. Approximately 5½ million bushels of Foundation and Foundation A were produced, out of a total of 12¾ million bushels from fields passing inspection in the three classes.

Shipments from the 1948 crop to March 31, 1949, totalled 6,670,095 bushels, of which 6,070,322 bushels were exported to 16 countries and 599,763 bushels were sold to domestic markets. Exports to the United States alone accounted for over 5 million bushels.

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## DIVISION OF ANIMAL PATHOLOGY

The Division of Animal Pathology has in addition to its central institute (Animal Diseases Research Institute, Hull, Que.) six branch laboratories located at Saanichton, B.C., Vancouver, B.C., Lethbridge, Alta., Macdonald College, Que., Sackville, N.B., and at the Central Experimental Farm, Ottawa.

The year has been one of great activity and although the Division has not been able to obtain sufficient scientific staff, considerable advancement has been made in the various fields of research.

The work of the Division is classified under three headings—Research, Services, and the Manufacture of Biological Products.

### Research

*Infectious Mastitis.*—No marked progress has been made in the study of this infection except to indicate the importance of certain factors relating to chemotherapy. The value of penicillin and some of the other antibiotics is well established and the investigations during the year have in large measure related to the practical application of these substances.

*Infectious Abortion* (Bang's Disease).—The most efficient means of raising the resistance of animals against this disease is an attenuated live organism. Obviously, this has many disadvantages and it follows that if a method could be evolved permitting the use of a killed organism, many difficulties would be overcome. Experiments during the year have related to this. It was hoped by the use of hyaluronidase or some of the so-called 'spreading factors' that organisms might be so distributed in the tissues that they would stimulate the immune mechanism and thereby call forth a considerable degree of resistance. No success has followed the many experiments along these lines and it is believed that there must be some definite biochemical change in the structure of the organism accompanying its death.

*Coccidiosis of Chickens.*—Successful research in this field over a number of years has led to the establishment of means whereby birds may become immune to the infective agent by regulating with chemical substances the degree of infection during the critical period. Many substances have been explored and a reasonable degree of basic knowledge has been established to deal successfully with this disease, which at one time played havoc with the poultry industry.

*Pullorum Disease.*—Pullorum disease, one of the causes of enormous economic loss to poultrymen, has almost been controlled by the application of research findings which have been made during the last few years. A committee representative of workers in the various Provincial Institutions and this Division has been formed in order that a completely co-ordinated program of research could be adopted. Great benefit has followed and the majority of the barriers which stood in the way of control and elimination of pullorum disease in chickens have been removed.

Pullorum disease of turkeys, however, is a different problem and intensive investigation is going on in this field in the hope that ultimately there may be as comprehensive a knowledge of the infection in these birds as in chickens.

*Enterohepatitis of Turkeys.*—This is the most important disease of turkeys and measures the limits of turkey production in Eastern Canada. The infection is passed from chickens or other birds to turkeys and because of this the latter must be raised away from either direct or indirect contact with chickens. Practical observation indicates that in Western Canada this is not so necessary as only in rare instances do turkeys become affected by contact with chickens. This is caused by a small worm which infests chickens and carries another parasite which in turn infects turkeys. It has been observed that this worm in Western Canada is not a disease-carrying parasite. The reason for this is not clear.

Basic information has been discovered which relates to the invasion of the turkey and it is hoped to be able to devise means for a better control of this infection.

*Rhinitis of Swine.*—Following the discovery that there were two conditions presenting somewhat similar symptoms, one an infection and the other a congenital deformity, it has been possible to carry on investigations with more precision. Obviously, the congenital deformity is one which can be corrected by breeding methods. Infectious rhinitis has therefore received considerable research study. Results indicate that it is caused by an infectious agent or agents but so far the specific cause has not been determined. Experiments suggest that there are two agents present which act symbiotically but this has not yet received positive proof. Apparently, only the small piglet is susceptible and therefore the infection must be contracted in the early weeks of life. There are many factors which must yet be explored and it is hoped in the course of one or two years to have more definite information.

*Tuberculin Studies.*—An investigation has been going forward for a number of years with the objective of producing a tuberculin with a high potency and a so-called narrow antigenic coverage. There are several organisms closely related to the bovine tubercle bacillus which sensitize cattle to a degree. The tuberculins employed at present do not differentiate these sensitizations. An intensive study has resulted in finding at least two strains of bovine tubercle bacilli which produce a tuberculin which tends to cause reactions only in animals infected with the bovine type. If success follows this investigation it will go far to eliminate some of the difficulties which are world-wide in the application of tuberculin in that animals react which are sensitized with acid-fast organisms other than bovine tubercle bacilli.

*Serological Studies.*—Great progress has been made in evolving methods to discover specific antibodies in the serum, particularly of birds. A new method which has been developed in this Division and which has been named the "indirect" complement fixation test has now reached a state of perfection in which it may be used as a supplemental test in research work to indicate more specifically the relationship of a number of infectious agents. It may also be of interest to state that it has been adopted in several of the leading research laboratories in other countries and is being used to study the relationship of certain organisms causing disease in animals and man.

*Newcastle Disease.*—Newcastle disease of poultry has been discovered in Canada and has led to an investigation of certain factors. Field observations strongly suggest that the infective virus may be passed by the medium of the egg. Many experiments have been conducted but up to the present efforts to transfer infection from adult to chick through the egg, have not been successful. It has been discovered however, that antibodies produced in the adult bird pass into the egg and may be passed on to the chick, where they remain for several weeks.

Experiments have been made in the production of an inactivated virus vaccine. It is felt that live virus should not be used in this country and consequently attention has been given only to a vaccine having no capacity for producing disease. A fairly satisfactory biologic has been worked out, which has a capacity of protecting susceptible birds for several months.

## Services

Laboratory services are given to veterinarians, physicians, livestock owners and others. These services are made up of a number of diverse types of work, including post mortem examinations, serological and bacteriological tests, parasitological and pathological studies. Much work has been conducted for other Departments, such as the examination of chemical substances which are claimed to have certain values and which are presented for registration. A considerable amount of time is also given to reviewing, for other Departments, the literature broadcast and matters relating to the protection of the public against exploitation.

| | |
|---|---|
| *Serological Tests for Bang's Disease* | |
| Animal Diseases Research Institute, Hull, Que. | 144,354 |
| Veterinary Research Laboratory, Lethbridge, Alta. | 13,719 |
| Pathological Laboratory, Saanichton, B.C. | 1,338 |
| Pacific Area Branch Laboratory, Vancouver, B.C. | 8,855 |
| Maritime Area Branch Laboratory, Sackville, N.B. | 4,461 |
| Montreal Area Branch Laboratory, Macdonald College, Que. | 1,631 |
| *Serological Tests for Pullorum Disease* | |
| Veterinary Research Laboratory, Lethbridge, Alta. | 209 |
| Poultry Pathology Laboratory, Ottawa, Ont. | 2,335 |
| *Miscellaneous Specimens and Post Mortem Examinations* | |
| Animal Diseases Research Institute, Hull, Que. | 658 |
| Veterinary Research Laboratory, Lethbridge, Alta. | 201 |
| Pathological Laboratory, Saanichton, B.C. | 299 |
| Pacific Area Branch Laboratory, Vancouver, B.C. | 532 |
| Maritime Area Branch Laboratory, Sackville, N.B. | 97 |
| Montreal Area Branch Laboratory, Macdonald College, Que. | 206 |
| Poultry Pathology Laboratory, Ottawa, Ont. | 896 |

## Manufacture of Biological Products

Biological products are manufactured on a large scale and these are issued to Veterinary Inspectors, to other Departments and to persons engaged in the diagnosis or control of animal diseases. The following is a summary of the products distributed this year:

| | |
|---|---|
| Tuberculin | 2,877,102 doses |
| Mallein | 6,966 " |
| Johnin | 855 " |
| *Brucella abortus* antigen — Tube Test | 147,339 test doses |
| — Rapid Test | 20,066 " " |
| Pullorum disease antigen | 268,500 " " |

## DIVISION OF BACTERIOLOGY AND DAIRY RESEARCH

### Dairy Research

*Milk.*—In co-operation with the Animal Husbandry Division, Experimental Farms Service, further tests have been conducted to determine the effectiveness of a number of newer products for cleaning and sanitizing milking machines. An acid type cleanser was found to be fairly satisfactory in hot solution, but not in cold. Three of the new detergent-sanitizers in cold solution also gave results inferior to those obtained from the method developed in this Division consisting of treatment in weak lye solution following a cold water rinse.

On many dairy farms, penicillin is used to treat udders of cows suffering from mastitis. Herd milks may therefore contain sufficient penicillin to interfere with bacterial growth, and so lead to erroneous results in the grading of milk by resazurin and methylene blue reduction tests. Studies have shown that resazurin reduction is rarely affected in the early stages; hence the grading of milks by the 'triple reading' test is unlikely to be influenced by the presence of penicillin. However, where complete reduction is taken as the end-point, as in the methylene blue test, this may be delayed by 6 hours or more and thus interfere with the reliability of the test.

The program for control of chronic contagious mastitis, in co-operation with the Animal Husbandry Division, has been continued. No evidence of infection with *Streptococcus agalactiae*, the causative organism, has been noted on six consecutive tests during the past three years. The bacteriological control of the Central Experimental Farm dairy operations was maintained during the year.

*Butter.*—Further studies have been made to compare the keeping quality of print butter in aluminum foil and parchment wraps when stored at 10°F. and 30°F. for 4 to 7 months. The aluminum foil wrap was found to give greater protection than parchment to flavour quality, especially at the surface of the prints. Whereas most of the parchment-wrapped butter lost from 2 to 3 points in flavour score at the surface after 4 to 7 months' storage, the butter in aluminum foil lost only 0.5 to 1.0 in flavour score, but still remained of first grade quality. The foil-wrapped butter also maintained better colour at the surface than did the butter in parchment. The possibility of storing high quality print butter in aluminum foil wraps at cold storage temperatures of 10°F. or lower for periods up to 7 months without loss of grade is indicated by these trials.

*Cheese.*—Studies previously reported have shown that rancidity can be reproduced experimentally in cheddar cheese by the addition of lipase from different sources and by activating milk lipase under special conditions. While these findings have offered a partial solution to the problem, they have not been acceptable to the industry as a complete answer to the cause of the defect under commercial cheesemaking conditions. Working on the assumption that rancidity may be of bacterial as well as of biochemical origin, studies were undertaken to determine the relationship of lipolytic bacteria to rancid flavours. Studies in cheese manufacture have shown that such flavour defects as not clean, slightly rancid, and rancid can be reproduced experimentally in cheddar cheese by the addition of lipolytic bacteria to the cheese milk supply. An analysis of the results of 28 experimental vats of cheddar cheese made from milk with the addition of varying percentages of lipolytic bacteria showed consistently lower flavour scores and higher acid values than uninoculated vats during the manufacturing process and storage period. The flavour defects found by the cheese graders were typical of those encountered in commercial grading. While the extent of contamination with lipolytic bacteria in cheese factory milk is not known, their presence in large numbers suggests that these organisms may be a cause of the sporadic occurrence of rancid flavours in commercial cheddar cheese.

A new type of bacterial spoilage in Canadian process cheese, involving considerable financial loss, was investigated. The defective cheese were gassy with a very obnoxious, penetrating odour, making them quite inedible. The responsible organism, identified as *Clostridium sporogenes*, was isolated from spoiled cheese and from samples of stock skim-milk powder used in the manufacturing process. While the use of high percentages of skim-milk powder has been found to have a bearing on the development of the defect, other factors such as number of organisms and growth-promoting factors added with the skim-milk powder appear to be involved in reproducing the defect experimentally.

Following suggestions from New Zealand that extensive use of penicillin for the treatment of bovine mastitis may result in the presence of sufficient amounts of the antibiotic in milk to interfere with normal acid development in starters used in cheesemaking, this possibility was further investigated. Tests with mixed and single-strain starters showed that complete inhibition of acid production was effected by 100 units, and virtually complete stoppage by 50 units of penicillin per 100 ml. milk. Partial inhibition was evident with 0.5 to 5 units. Pasteurization of the milk containing the antibiotic failed to inactivate it, though the addition of penicillinase, a penicillin destroying enzyme, permitted normal acid development.

A number of techniques were studied with a view to selecting the most accurate method for determining the numbers of lipolytic bacteria in cheese factory milk supplies and in defective cheese. The use of a butterfat emulsion incorporated into nutrient agar containing Nile blue sulphate as an indicator of lipolysis was found to be useful for the identification of fat-splitting organisms, but did not prove to be sufficiently accurate for determining total numbers. A modification of the method advanced by Demeter and Eisenreich was found to give the most accurate and consistent results, and is proposed as a routine test for estimating numbers of lipolytic bacteria in cheese factory milk supplies.

*Dry Milk.*—The analysis of dry skim-milk for grading purposes was continued by the Division. During the year, 12,326 samples of roller- and spray-dried skim-milk were analysed for sediment, acidity, colour, flavour and bacteria counts. Of the total samples, 15·6 per cent were spray-dried and were also tested for solubility index. Quality showed continued improvement with an increase of 16·4 per cent in the amount of first grade powder. Only 5·6 per cent of the powder was below second grade as compared with 14·2 per cent the previous year. The main defect in roller-dried powder was high sediment, but there was a marked reduction in the powder degraded for low acidity. For spray-dried powder, a high bacteria count was the principal cause of degrading the powder below first grade. High fat and moisture were next in importance as defects.

## Food Microbiology

*Dried Egg for Export to Britain.*—This Division has continued to share the responsibility for the maintenance of adequate sanitation in Canadian egg breaking and drying plants. Bacteriological analysis, and especially direct microscopic examination, of all Grade A carlots has directed attention to plants having difficulty in meeting bacteriological specifications. At the request of the British Ministry of Food, a switch was made from the production of sugared dried egg to plain whole egg powder at the end of June, 1948. Out of 176 carlot samples examined during 1948, only 3 failed to meet the bacteria count specifications, a marked improvement over the earlier years.

*Frozen Egg Products.*—Further assistance was given the Poultry Marketing Service in improving the bacteriological quality of frozen egg products, for domestic use as well as for export to Britain. A marked improvement in bacteria

count levels was noted during the year. In 1948, 16·3 per cent of 840 samples exceeded 1 million per gram in count as compared with 51·2 per cent of 960 samples for 1947. Conversely, 59·8 per cent were below 250,000 per gram in 1948, and 26·2 per cent in 1947.

Comparisons of the results by the Burri slant and plate count methods on frozen egg have shown a satisfactory agreement on counts not exceeding 500,000 per gram. Much time and money may thus be saved by having inspectors make Burri slant determinations at the time of sampling, and submitting for plate count analysis only samples exceeding the above limit. Comparisons of numbers of coliform organisms with total counts have shown a very low degree of correlation between these two indices of quality.

*Frozen Pack Vegetables and Fruits.*—The bacteriological survey of commercial packs of frozen vegetables and fruits was continued at the Ottawa and Summerland laboratories. Of the vegetables, 32·3 per cent had bacteria counts below 100,000 per gram, while coliform organisms were present in 0·1 gm. portions of 75·5 per cent of the samples. In contrast, 98·4 per cent of the counts of the fruits were under 100,000 per gram, while 57·1 per cent had yeast counts and 30·1 per cent mould counts below 1,000 per gram. Marked variations in count levels were noted from plant to plant, again emphasizing the need for closer supervision in certain establishments.

Studies were continued on the effect of freezing of pure cultures of bacteria isolated from fresh products. While thermophilic bacteria died off rapidly during the early hours of freezing, the behaviour of mesophiles and psychrophiles was unpredictable. The phase of growth of the test organism appears to be important here, older cultures generally being more resistant to freezing. Vegetable extracts and sugar (over 5 per cent) afforded some protection against freezing, while fewest survivors were noted when the organisms were suspended in water or 3 per cent sodium chloride.

In studies of the effect of blanching it was found that the indigenous microfloras of peas were able to grow much more rapidly at room temperature on blanched than on unblanched peas. In tests with cultures of certain chromogenic indicator organisms artificially inoculated, *Serratia marcescens* and *Sarcina lutea* died off rapidly on unblanched but increased greatly on blanched peas. Though this effect is regarded as attributable to the release of nutrients by the blanching which are favourable to microbial growth, there are indications that in the unblanched product the indigenous flora may exert an antibiotic effect on certain other organisms.

Further studies at the Summerland laboratory have confirmed the superiority of the test for enterococci over the coliform test as an index of contamination in frozen-pack vegetables. While coliform organisms appear somewhat more frequently in freshly packed samples, after storage the enterococci serve as better indicators of original contamination due to their greater longevity in the frozen product. *Streptococcus faecalis* was the commonest species of enterococcus isolated, with *S. liquefaciens* occurring in smaller numbers. A comparative study of 508 cultures of coliform bacteria from 108 samples of commercial frozen vegetables showed the majority to be *Aerobacter aerogenes* (53 per cent). *Escherichia coli* comprised only 3 per cent of the cultures, the remainder being intermediate types (44 per cent). Little change in proportion was noted after storage for 1 year at –4°F.

*Canned Fruits and Vegetables.*—The examination of canned tomato products, using the mould content as a criterion of quality, was continued during the year in co-operation with the Fruit and Vegetable Division, Marketing Service. In all, 3,625 samples were analysed at laboratories in Ottawa, Toronto and Summerland, compared with 2,134 in 1947. There was a definite over-all improve-

ment in quality, only 7·9 per cent of samples exceeding the established limit in 1948 compared with 12·8 per cent in 1947. However, unusually wet weather in British Columbia probably increased the percentage exceeding the limit there from 14·8 per cent in 1947 to 27·5 per cent in 1948. Most packing plants maintained or improved the quality of their products during 1948.

Studies of an abnormal spoilage of canned beets, resulting in a black discoloration, showed that the blackening was due to the action of bacteria which secrete the enzyme tyrosinase. In the presence of the amino acid tyrosine, present in the beets, and iron, probably derived from the equipment during processing, the organisms are able to produce black pigments. The fault is definitely due to under-processing.

*Miscellaneous.*—At the request of the Fruit and Vegetable Division, Marketing Service, studies were undertaken at the Summerland laboratory to determine the load of moulds carried on new and used strawberry hallocks. Data collected from eight packing and processing plants in the Vancouver area showed a definite relationship between visible discoloration as a result of previous use and the amount of mould contamination. Although stained and dirty hallocks are definitely a greater menace, even unused ones are sufficiently seeded with mould spores to be a source of infection to fruit if conditions are conducive to spoilage.

The Howard mould counting technique used for the official control of tomato products was studied for its applicability to the analysis of jams. Results from tests of 232 jams from British Columbia plants indicated that those from berries generally gave higher counts than those from stone fruits, 35 per cent of the former exceeding the 15 per cent tolerance established by the U.S. Food, Drug and Cosmetics Act. Wide variations in counts were noted between products from different plants.

In co-operation with the Health of Animals Division, Production Service, the bacteriological control of edible gelatine was continued. Of 1,637 samples analysed during the year, 95·8 per cent met the bacteriological standards set by the Food and Drugs Act, as compared with 96·6 per cent in 1947. However, only 0·2 per cent of counts exceeded 50,000 per gram, compared with 0·8 per cent in 1947.

## Soil Microbiology

*Specific Effects of Crops on Soil Bacteria.*—A statistical analysis was completed of data obtained from a comparative study of the effect of six different crop plants—wheat, oats, red clover, alfalfa, timothy and flax—on the bacterial flora of soil, with special reference to the balance between organisms in the rhizosphere of different nutritional requirements.

Significant differences in rhizosphere effect between certain crops were noted with respect to five groups of bacteria, viz. those with simplest nutritional requirements (inorganic nitrogen) and those requiring, respectively, amino acids, growth factors, amino acids plus growth factors, and substances present in yeast extract. In the main, specific differences existed between red clover, alfalfa and flax on the one hand and wheat, oats and timothy on the other. The legumes, however, differed from flax with respect to bacteria requiring amino acids.

Such studies are being developed with the object of providing better basic information on the mutual relationships between crops and soil micro-organisms helpful to a better understanding of problems relating to plant growth, crop sequence and soil-borne diseases.

*Soil Micro-organisms in Relation to Manganese Deficiency.*—Following field tests on the effect of soil treatments on manganese deficiency of oats, which showed highly favourable results from the application of certain soil fumigants, particularly cyanogas, greenhouse tests were carried out with the co-operation of the Division of Chemistry to study the effect of selected treatments on the microbiological activity of the soil and on the content of available manganese.

The application of cyanogas reduced significantly the numbers of manganese-oxidizing, denitrifying and cellulose-decomposing organisms. Although the first two groups regained their numbers after three months, the cellulose-decomposing organisms remained depressed to the end of the experiment (10 months). Application of manganous sulphate or straw mulch, on the other hand, increased the activity of all the above-mentioned groups of organisms. The level of water-soluble manganese was not affected by the various treatments. However, replaceable manganese was much higher in cyanogas-treated soil than with any other treatment, while easily-reducible manganese was consistently highest following manganese treatment. A negative correlation was shown throughout the experiment between the level of replaceable manganese and the density of cellulose-decomposing organisms, and a low incidence of the latter in the soil was related to the correction of manganese deficiency by cyanogas treatment as shown by the growth of the indicator crop.

*The Microbiological Equilibrium in Soil in Relation to Potato Scab.*—The relation of the beneficial effect of incorporating soybean crops with scab-infested soil to the microbiological equilibrium in soil was further studied at St. Catharines in co-operation with the Division of Botany and Plant Pathology. The stimulatory effect of soybean decomposition on bacteria requiring amino acids for growth, as well as a negative correlation between the 'bacterial balance index' and scab incidence, was further emphasized. Unlike the bacteria, the actinomycetes in the soil and the potato rhizosphere were found to be stable with respect to their nutritional requirements regardless of soil treatment.

Pathogenicity tests on actinomycetes isolated on a non-selective basis indicated a reduction in parasitic forms in soybean-treated soil, as well as in the rhizosphere of potatoes subsequently grown in this soil, as compared with the corresponding controls. At the Ottawa laboratory, the same actinomycetes were examined for antibiotic properties against *Staphylococcus aureus*, *Escherichia coli* and *Streptomyces scabies*. The outstanding feature of the results was a notable increase in the percentage of strains antagonistic to *S. scabies* in the potato rhizosphere of the soybean-treated soil, as compared with the soil receiving no treatment (12·2 per cent as compared with 0·9 per cent).

In a field survey extending over six months in southwestern Ontario, no relationship was observed between numbers of soil actinomycetes and the incidence of scab, little variation being noted regardless of soil type or treatment.

*The Bacterial Flora of Seeds.*—Comparative studies were begun during the year on the nature of the bacteria associated with the seeds of various crop plants, as one aspect of an investigation to consider also the rhizosphere effects and decomposition effects of the same crops in soil.

Organisms isolated on a non-selective basis from washed and macerated samples of oats were strikingly uniform in type, contrasting with those common to soil with respect to diversity of species and physiological character. The same was true for bacteria from wheat, though the types possessed characteristics somewhat different from those of organisms from oats. The results suggest that there is a group of bacteria indigenous to seeds, though much more work remains to be done to determine to what extent seeds have their specific microflora. Many of the types isolated were found to be antagonistic to other micro-organisms. Thus, out of 200 isolates from wheat, 26 per cent showed antagonism to *Helminthosporium sativum*.

*Miscellaneous.*—A study has been completed of the action of fifty strains of antibiotic actinomycetes, isolated from soils of widely separated regions, on a variety of soil bacteria including species of *Azotobacter*, *Rhizobium*, *Xanthomonas*, *Corynebacterium* as well as miscellaneous other types. A wide range of susceptibility was noted, though Gram-positive forms were suppressed by the greatest number of actinomycetes. It was also noted that the strains of actinomycetes which showed antagonism towards the greatest numbers of bacteria were found to possess the most intense antibiotic activity.

In studies of the relationships of different plants to soil micro-organisms, observations were made of the effect of the horse-radish plant, since this is known to accumulate volatile mustard oil in the root. Although extracts of roots were found to have a depressing effect on fungi, yet the growing plant showed a characteristic 'rhizosphere effect' in stimulating bacteria and fungi in soil adjacent to the root, thus indicating that there is no diffusion of mustard oil into the soil in amounts sufficient to affect soil organisms.

## Miscellaneous Investigations

*Foulbrood Diseases of Bees.*—The use of sulphathiazole for the control of American foulbrood was investigated under field conditions in co-operation with the Bee Division, Central Experimental Farm. The drug was fed at the rate of 0·5 grams per gallon of 50 per cent sugar syrup inoculated with 2 billion spores of *Bacillus larvae* and prevented infection of bee larvae, whereas unmedicated, inoculated syrup produced severe infection. Infected colonies were almost entirely cleaned up by drug feeding, the bees removing dead larvae and scaly material and rearing healthy brood. When para-aminobenzoic acid, a potent sulpha drug inhibitor, was fed along with sulpha and spores, infection of the larvae occurred.

*In vitro* studies showed that different strains of *B. larvae* varied in their sensitivity to sodium sulphathiazole though all were inhibited and most of them killed in a one per cent solution. The composition of the medium, size of inoculum and other factors affected their sensitivity. The organisms could be adapted to grow in one per cent of this drug but rapidly lost this ability when cultured in its absence.

Experiments on the age of susceptibility of larvae to American foulbrood, involving spraying of larvae of different ages with heavy suspensions of spores, showed that larvae more than 54 hours old were not susceptible.

*Disinfectants and Antibiotics.*—Extensive studies were made to seek an explanation for the contradiction between the results of English workers, who recently reported no significant difference in germicidal speed of hypochlorite solutions between pH 7 and 11, and those of previous workers who found less alkaline solutions to be more effective. It was found that where the test organisms are dried on a thick film of milk, as in the English studies, solutions of high and low alkalinity are equally effective. However, in the case of thin, dried films of milk or moist films, the neutral hypochlorite is a more effective germicide than the more alkaline. The effect is therefore related to the concentration of milk solids under the test conditions. Since hypochlorite solutions are intended for use on washed equipment and utensils, the less alkaline types are definitely preferable for purposes of practical sterilization in the dairy and food industries.

Additional information was obtained on the effect of various antibiotics on sugar-tolerant and other yeasts. Subtilin, bacitracin and aureomycin, as well as penicillin and streptomycin, were relatively ineffective against all species tested. However, clavacin and streptothricin were considerably more effective in inhibiting the strains of *Saccharomyces cerevisiae* and *S. ellipsoideus* studied.

*Nutritional Requirements of Bacteria.*—Supplementing previous work on the organic requirements of *Pseudomonas nigrifaciens*, an organism which causes dark surface discoloration of printed butter, the inorganic requirements were determined. Magnesium, potassium and phosphorus were required for maximum growth and pigment production. Iron was essential for rapid pigment formation by some strains, though manganese was without apparent influence. Sodium chloride was essential (both the sodium and chlorine ions being required for growth and pigmentation) at an optimum range of 1·5 to 3·0 per cent.

*Microbiological Assay of Vitamins and Amino Acids.*—Microbiological assay methods for vitamins and amino acids are becoming increasingly important in nutritional studies. Co-operative work with the Division of Chemistry, particularly on the riboflavin and lysine content of various feeding stuffs, has been in progress for several years. More recently, co-operation has been extended to the Forage Crops Division through riboflavin assay studies with various grasses and legumes. For the preparation of the samples, different methods of extraction were studied. More uniform results followed the enzyme extraction, though the acid procedure yielded, on the whole, slightly higher values.

### Services

The general analytical service was continued during the year, chiefly in co-operation with other divisions of the Department. This work entailed the examination of 18,801 samples as compared with 13,533 samples during the previous year. Milk powders accounted for 13,668 samples, the remainder including other dairy products, egg products, gelatine, fruit and vegetable products, honey, foulbrood specimens, legume inoculants and feeding stuffs. The work was done chiefly in connection with the control of agricultural products within the scope of Acts and Regulations administered by the Department. In addition, 132 cultures for the inoculation of legume seed were prepared for Experimental Farms and Illustration Stations.

## DIVISION OF BOTANY AND PLANT PATHOLOGY

### Botany Section

*Systematic Botany.*—During 1948, work in the general field of systematic botany was greatly advanced by close co-operation with the Defence Research Board in investigations in northern Canada. Valuable collections of vascular plants, lichens, mosses and algae, perhaps the most extensive ever to be made in arctic regions, were obtained from four chief areas. These collections were identified or submitted to specialists for examination and will fill a serious blank that has existed in the collection of the Division. Many duplicates are now available for distribution to other institutions for which it is hoped foreign material will be received in exchange. Field work elsewhere was considerably curtailed save for short trips into Ontario to study grasses. Co-operative investigations with Professor E. H. Moss in Alberta were continued and projects with Dr. J. H. Soper of University of Toronto, Dr. N. Radforth of McMaster University, and Dr. A. E. Roland of the Nova Scotia Agricultural College were initiated. The herbarium continued to expand with the accessioning of 14,017 specimens. It now contains slightly over 100,000 mounted specimens and is becoming a valuable working unit for distributional and variation studies on weeds as well as wild and cultivated plants. Identification of plants for the public continued to be a major service offered by the herbarium staff.

Considerable progress was made towards the verification of the identity of the shrubs and trees growing in the Dominion Arboretum and Botanic Garden. Over 1,000 specimens collected in previous years were examined and further

collections to complement these were made. Critical taxonomic studies have been made of several groups of Canadian plants. Such studies have resulted in 6 species, 17 varieties, and 10 forms previously not recognized in our flora being described as new to science. Revisionary work extended to all sections of the herbarium, revealing the fact that about one third of all specimens identified two or more decades ago require annotations to bring them in line with current concepts.

*Phenological Observations in 1948.*—A comparison of the first date of anthesis for marker plants at Ottawa in 1946, 1947, and 1948, together with the number of days that the 1948 observations depart from the average date of flowering, is given in the following table:

| Marker plant | 1946 | 1947 | 1948 | Departure from average for 1948 in days |
|---|---|---|---|---|
| Silver maple | March 21 | April 12 | April 5 | 6 early |
| American elm | April 7 | May 6 | April 22 | 3 early |
| Sugar maple | May 8 | May 19 | May 6 | 2 early |
| Scotch pine | June 1 | June 10 | May 30 | 2 late |
| Bitternut hickory | June 16 | June 23 | June 13 | 1 late |
| American basswood | July 10 | July 18 | July 10 | 4 late |
| Japanese knotweed | Sept. 4 | Sept. 7 | Aug. 28 | 4 early |
| Witch hazel | Sept. 19 | Oct. 6 | Sept. 26 | 2 early |

The 1948 season opened at Ottawa on April 5 with the flowering of silver maple, six days ahead of the average date for this species. Subsequently, the advance of the season lagged somewhat, and as a result, the season was approximately average by May 1. It then continued approximately average for the duration of the summer.

*Herbicide Registration.*—Applications for registration of herbicides totalled 131 as compared with 91 in 1947, and 56 in 1946. Various formulations of 2,4-D accounted for 117 of the year's applications. Three oils have been registered for the control of weeds in certain umbelliferous crops.

The 117 applications for registration of 2,4-D products comprised the following: for sodium salts, 19; amines, 55; esters, 26; dusts, 16; and for a tablet product, 1. Applications for esters and dust preparations have shown the greatest increase.

*National Weed Committee.*—The Second Western Canadian Weed Control Conference organized by the Western Section of the National Weed Committee attracted 309 weed workers, 247 being from the Prairie Provinces, 25 from other parts of Canada, and 37 from the United States. The meetings were highly successful and the reports and recommendations from the Conference promise to be the yardstick for chemical weed control in Western Canada and the bordering United States during 1949.

An Eastern Canadian weed workers' meeting was held by the Eastern Section, in co-operation with the Central Experimental Farm, at Ottawa, in January, 1948. The previous year's results in weed research were reviewed. Conflicting results were reported on the control of weeds by means of 2,4-D in crops seeded down to clovers. With most perennial weeds variable results were obtained. A resolution was passed calling for an increase in the basic research on weed control.

*Weed Survey.*—The survey was confined to southwestern Ontario, the Mattawa valley, and the Ottawa district. Numerous extensions of range, including several new provincial records, resulted from these trips and from collec-

tions sent in by collaborators from across Canada. Goutweed (*Aegopodium Podagraria*) and nutgrass (*Cyperus esculentus*), weeds difficult to control, are apparently increasing in the East, if collections and enquiries from the public are indicative. Carrion-flower (*Smilax herbacea*) in its western variation has been received for identification frequently enough to suggest that it is advancing in the West.

Visits to known infestations of dodder in Ontario and Quebec, and reports from inspectors and weed workers in the West, indicate that the acreage of dodder is increasing. Three species, namely, *Cuscuta campestris*, *C. Gronovii* and *C. curta*, are largely responsible for this increase, with the latter species being most important. Valuable crops, such as flax, red clover, and alfalfa, are attacked, with the result that more and more farms are compelled to use restricted rotations.

Weed survey has reached a point where most of the species and their general distribution are known. It is now considered that individual groups of weeds should be studied more intensively from ecological, taxonomic, physiological, and distributional viewpoints. A beginning has been made with five genera of thistles. The relationship of some of the important weeds in the group to soil texture and soil moisture was investigated. The difficult taxonomic aspects of the problem necessitated extensive collections of living plants, pressed material, and seeds. A nursery, to include native and introduced thistles, has been started. One of the most interesting field observations was a serious mixed infestation of Scotch thistle (*Onopordon Acanthium*) and globe thistle (*Echinops sphaerocephalus*) covering several hundred acres at Goderich, Ont.

The Sixth (1947) Report of the Dominion Weed Survey was compiled during the year.

*Some Effects of Herbicidal Oils on the Physiology of Umbelliferous Crop Plants and Weeds.*—Certain oil fractions are being used extensively to control weeds in fields of carrots and parsnips. As yet, however, little is known of how these oils kill the weeds and at the same time cause no apparent injury to the crop. Experiments were initiated to investigate the mechanism of this selective action of the herbicidal oils.

By means of the infra-red absorption apparatus, the time course of photosynthesis, respiration, and transpiration was studied for leaves of carrot, parsnip, common mustard, lamb's quarters, and common chickweed following the application of a petroleum naphtha (boiling range 300°-400°F.). This oil disrupted completely and immediately the photosynthesis of all plants tested, regardless of whether the plants were susceptible or not susceptible to injury from the oil. This disruption of photosynthesis, although permanent for mustard, a plant rather easily killed by application of herbicidal oils, was, however, temporary for parsnip, a species not readily injured. Parsnip, therefore, was apparently able to survive the application of oil, but the mustard was killed. The respiration rate of parsnip leaves increased slightly and remained at the higher level for five days after the application of the oil. With mustard leaves, the respiration rate gradually decreased until it reached zero approximately two hours after the oil was applied. Transpiration ceased permanently in the mustard on the application of the petroleum naphtha to the leaves but, in parsnip, it recovered after a temporary reduction to 20 per cent of the normal rate. The transpiration studies suggest that interference with or stoppage of the water supply to the leaf cells was responsible for the sudden disruption of photosynthesis in the two plants and accounted for the difference in the recovery of photosynthesis between parsnip and mustard.

*Effect of Bordeaux Mixtures on the Physiology of Potato Plants.*—By means of the infra-red absorption apparatus, results have been obtained indicating

that a 4-4-40 bordeaux mixture retards the rate of photosynthesis, whereas a 4-2-40 bordeaux mixture has a stimulating effect. Neither mixture affected the rate of respiration.

*Cytogenetics of Agropyron.*—About 150 accessions of arctic grasses were added to the grass collections during the summer. Many of these belong to genera other than *Agropyron.* The various species show a wide range in chromosome number; aneuploidy occurs in several genera: *Arctagrostis*, $2n = 56$; *Alopecurus*, $2n = 105, 112, 119$; *Calamagrostis*, $2n = 140$; *Deschampsia*, $2n = 38, 42$; *Dupontia*, $2n = 38, 42$; *Festuca*, $2n = 28, 42, 50, 56, 78$; *Hierochloë*, $2n = 56$; *Poa*, various numbers from 42 to 106; and *Puccinellia*, $2n = 14, 21$.

Seven populations of artificial intervarietal hybrids of *Agropyron trachycaulum* and the interspecific hybrid *A. trachycaulum* × *A. caninum* have been grown. From a morphologic comparison of these plants with their parents, it is concluded that the former are actually hybrid. Meiosis is irregular in all and a high percentage of the pollen grains are empty. A survey of meiosis in 89 plants of the six varieties of *A. trachycaulum* has disclosed consistent irregularities only in the variety *pilosiglume.* This variety is believed to be a natural interspecific hybrid.

*Cytogenetics of Caragana.*—The caragana plantings were increased and determination of chromosome number was continued. The chromosome number has been determined for about 20 species; in addition to species previously reported, *Caragana Boisii*, *C. brevispina*, *C. conferta*, and *C. sibirica* are diploid, $2n = 16$; and *C. chamlagu* and *C. Franchetiana* are tetraploid, $2n = 32$.

*Dominion Arboretum and Botanic Garden.*—Spraying of the lawns in the Arboretum with 2,4-D was continued for the third successive year. A noticeable decrease in the dandelion population has resulted, although a large number of seedlings appears each year as a result of seed being blown in from adjacent areas. Some 8,500 hardwood cuttings were taken from 300 species and varieties of trees and shrubs. A total of 4,230 packets of seeds was sown during the year. The nurseries now contain 5,900 plants of trees, shrubs, and herbaceous perennials.

A new garden for native plants has been developed at the northwest corner of the Arboretum. Work on the excavation of the lake at the southeast corner of the Arboretum has made steady progress. Since work on this project can only be carried on during winter when the swampy land is frozen, it is necessarily slow. Twenty-four numbers of Volume 3 of "This Week in the Arboretum", a weekly sheet containing information on plants in flower or of interest during the spring and summer, were issued in 1948.

*Seed Exchange.*—The work in connection with the seed exchange increased considerably during 1948. Various quantities of seeds were collected from identified species of trees and shrubs growing in the Dominion Arboretum and Botanic Garden. The Index Seminum was issued and listed 736 species and varieties of trees and shrubs, certain Canadian native and adventive plants, and (through the courtesy of the Experimental Farms Service) commercial varieties of cereals, forage plants, garden vegetables, fibre flax, and tobacco. It was mailed to 330 Botanic Gardens, Universities and similar institutions in Canada, U.S.A., and foreign countries.

As an increased demand for seed was anticipated, more seeds than usual were collected. Special attention was given to requests for aid in the rehabilitation of foreign institutions and letters of appreciation were received.

Altogether, 5,373 packets of seeds and 1,174 plants and cuttings were distributed in response to 266 requests from 36 foreign countries and Canada. In exchange, 2,566 lots of seeds and 137 plants were received from 112 Botanic Gardens and other institutions.

## Forest Pathology

*Winter Injury.*—During the spring of 1948, coniferous trees generally throughout Eastern Canada showed severe symptoms of this form of injury. The discoloration of the leaves became apparent from about mid-March on, but the damage had actually occurred some time previously. Winter injury or winter drying occurs during late winter or early spring when the temperature of the air surrounding the foliage becomes sufficiently high to cause the leaves to transpire. This is a normal process during the growing season when the water given off is replaced from the roots, but replacement is impossible when the ground is frozen. As a result the leaf tissues are killed and gradually dry out, the affected leaves becoming at first a bright reddish-brown colour, which gradually fades out.

Winter injury occurs to some extent every year, but the severe discoloration of foliage this year resulted largely from the abnormally high amount of sunshine during late February and early March. Added to this, the facts that the trees entered the winter season in a very dry condition owing to the drought of the previous fall and that the subnormal amount of snowfall during the ensuing winter allowed the frost to penetrate deeply into the ground, were important contributory factors. Although there were no unusually mild days during the early months of this year, it is the temperature of the air immediately surrounding the leaves, rather than the official temperature, which is significant. Since the injury is caused by an increase in temperature as a result of the direct rays of the sun, it follows that individual trees in exposed locations will be most seriously affected. Thus the exposed sides of such trees, i.e., south and west, are likely to show the most severe discoloration and trees in the interior of stands or on northern exposures are usually not affected. But winter injury does not occur uniformly and one tree may be severely affected while another of the same species close by may remain quite green. Usually it is the leaves formed in the previous year which are most seriously injured but sometimes these leaves are green and those of previous years are damaged. It is impossible to account for these variations.

As a group, the pines have been much more severely affected this year by winter injury than any other conifers, and, of the native pines, the white pine has been by far the most seriously injured. However, substantial damage has also occurred in spruce, cedar, and balsam fir, particularly in towns and cities. At first the injury appeared to be much more serious than it really was. In a few extreme cases, especially in small trees, all the leaves and buds were killed and the trees did not survive, but generally the damage was confined to a partial killing of foliage with a resulting decrease in the rate of growth. When the new shoots and leaves completed their growth, the appearance of the injured trees was remarkably improved. In the great majority of the affected trees, there was no permanent ill effect, the injury being confined to a temporary disfigurement of the trees and a temporarily reduced growth rate. Owing to the nature of the injury, there is no method of control.

*Smelter Fume Injury.*—A brief examination was made of the Sudbury district in mid-June, principally for the purpose of observing conditions in regard to winter injury in conifers there. As the symptoms of injury caused by sulphur dioxide and those of winter injury in conifers are very similar, it was felt that some record should be made of the condition of coniferous foliage in that area before there was any possibility of fresh symptoms of sulphur dioxide injury being present. Winter injury was found to be generally present in all directions from Sudbury, the injury being much more severe in some localities than in others. White pine was the species most severely injured. In young red pine growing in the open, a definite pattern of injury was observed. The lower 1½ to 2 feet of foliage and also the leaves in the upper part of the tree were

uninjured while the foliage in the central part was severely discoloured. This is apparently the result of the lower leaves being below the snow level at the time of injury and so not being subjected to high air temperatures. The leaves in the upper part of the tree were uninjured because the temperature of the surrounding air did not rise high enough to cause them to transpire, while in the central part of the tree the temperature was increased sufficiently by reflection from the snow surface to cause the leaves to give off moisture. No recent injury in conifers caused by sulphur dioxide was observed at this time. The three groups of trees which have been marked for annual examination showed general slight winter injury but apart from this were in good condition.

*Dutch Elm Disease.*—As in previous years, work on this project was carried on co-operatively by the Dominion Department of Agriculture (Divisions of Botany and Plant Pathology, Entomology, and Plant Protection), the Quebec Department of Lands and Forests, and the Ontario Department of Agriculture.

In Quebec, considerable intensification of the disease occurred in the eastern part of the infected area south of the St. Lawrence River. Infected trees were found in seven counties in which the disease had not been previously known to be present, making in all a total of 36 counties in the infected area. There was an extension of the known area of disease towards the south, infected trees being found within approximately 25 miles of the Maine border, within 16 miles of the New Hampshire border, and within 20 miles of the Vermont and New York borders. A total of 3,648 collections was made in Quebec and of these 2,581 proved to be positive. The policy of removing infected trees in the outer sections of the general area of infection was continued.

The most important development during the year was the discovery of a single infected tree with typical symptoms in the City of Ottawa. In addition, positive cultures were obtained from 13 other trees, which were either dead or dying, in six counties in eastern Ontario. These trees occurred sporadically and there is no apparent explanation either for the scattered distribution or for the fact that most of them were remote from the nearest known source of infection in Quebec. There is ample evidence to indicate that in no instance was the death or poor condition of these trees caused by Dutch elm disease. It is evident that the causal fungus has only recently reached Ontario and is existing as a saprophyte in dead wood and bark. This is important from the point of view of control. All 14 trees have been removed, but it will require the work of another field season to clarify the situation in Ontario in regard to this disease.

At Ottawa, 2,841 collections from trees in Ontario, Quebec, and New Brunswick suspected of having Dutch elm disease were cultured. The results obtained from this work are shown in the following table:

SAMPLES FROM 2,481 TREES SUSPECTED OF HAVING THE DUTCH ELM DISEASE

| Fungus isolated | Number of trees from which samples were taken | | | |
|---|---|---|---|---|
| | Ontario | Quebec | New Brunswick | Total |
| *Ceratostomella Ulmi* | 14 | 1,615 | 0 | 1,629 |
| *Cephalosporium* sp. | 16 | 137(+8)[1] | 2 | 155(+8)[1] |
| *Verticillium* sp. | 9 | 27(+4)[2] | 0 | 36(+4)[2] |
| Miscellaneous | 52 | 248 | 1 | 301 |
| Sterile | 56 | 271 | 1 | 328 |
| Negative | 201 | 191 | 0 | 392 |
| Totals | 348 | 2,489 | 4 | 2,841 |

[1] Eight samples yielded *Cephalosporium* in addition to *Ceratostomella Ulmi*.
[2] Two samples yielded *Verticillium* in addition to *C. Ulmi* and two, *Verticillium* in addition to *Cephalosporium*.

*Forest Mycological Collections.*—During 1948, 507 accessions were made to the collections of wood-inhabiting fungi in the Mycological Herbarium, Department of Agriculture, Ottawa. These include 128 cultures for which neither specimens nor rots were received. The number of entries for this section of the Mycological Herbarium now stands at 14,313. Dr. J. L. Lowe, of the New York State College of Forestry, contributed 24 collections of *Polyporus* and *Poria*, seven species of which were new to the Herbarium. Named specimens were also received from Dr. Dow V. Baxter, of the University of Michigan, and R. W. Davidson, of the U.S. Department of Agriculture. Forty-nine collections were exsiccati specimens from K. Starcs' "Flora Bavarica". Thanks are extended to these workers for their donation of specimens and to Dr. H. S. Jackson, of the University of Toronto, for identifying a number of Thelephoraceae. Collections, other than those added to the Herbarium, have been examined and identified but discarded either because they were in poor condition or because they were collections of the species on the same host and from the same locality already in the Herbarium. Thirty-nine specimens were sent in for identification from the Dominion Laboratory of Forest Pathology at Toronto and 154 from the Dominion Laboratory of Forest Pathology at Victoria.

*Cultural Studies of Wood-Destroying Fungi.*—The collection of cultures of wood-destroying fungi was increased by the addition of 131 named and 113 unidentified cultures. These included a valuable group, mainly of species of *Poria*, isolated from fruit bodies collected, determined, and submitted by Dr. J. L. Lowe, of the New York State College of Forestry, at Syracuse University. Cultures of 17 species not previously represented in the collection were added, bringing the number of named cultures in the collection to 1,604 in 433 species and 84 genera. The duplicate set of cultures was placed under mineral oil and tests made approximately ten months later showed that the cultures tested had survived without loss of vigour. This indicates that the mineral oil conservation method may be as successful for the Hymenomycetes as for other groups tested. In answer to requests from correspondents, 100 cultures were sent out during 1948.

During the year, 1,369 cultures isolated from rots encountered in the decay studies made on various species of trees in British Columbia, Saskatchewan, and Ontario by Dominion Laboratories of Forest Pathology at Victoria, Saskatoon, and Toronto, were received for identification. Of these, 312 were Hyphomycetes, including stain-producing organisms and contaminants for which no specific identification can be undertaken. Of the remainder, 859 or 81 per cent have been assigned to 38 species of Polyporaceae, 13 of Thelephoraceae, 3 of Hydnaceae, and 8 of Agaricaceae. Many of the 198 cultures still unidentified show cultural characters unlike those of any named species in the collection.

Of the cultures received from British Columbia, 158 were isolated during decay studies on *Pseudotsuga taxifolia*. These cultures belong to 16 species of which six had not been encountered previously among isolates from this host. *Polyporus Schweinitzii* occurred 54 times, indicating its importance as a cause of brown butt-rot in Douglas fir. Decay studies on *Picea glauca* in the Prince George region yielded 115 cultures of which 88 have been identified in 14 species. As in 1947, *Polyporus circinatus* was the species most frequently obtained, appearing 22 times. Members of the Thelephoraceae were remarkably abundant, being represented by five species. Deterioration studies on trees killed by the hemlock looper in Vancouver Island yielded 206 isolates of which 178 have been assigned to 11 species, mostly associated with decay in sapwood. The two most frequently isolated were *Fomes pinicola* (46) and *Stereum Chailletii* (49). No previous record is known of the association of the second species with decay.

Cultures were received from three major decay studies in Ontario, on *Acer saccharum*, *Pinus Strobus*, and on the group of hosts *Abies balsamea*, *Picea*

*glauca*, and *P. mariana*. Of 373 cultures from white pine, 240 have been assigned to 13 species, *Fomes Pini* (125) and *Corticium galactinum* (28) occurring most frequently. Forty identical isolates from a red basal stain and brown cubical rot are unlike any named cultures in the collection. In isolates from *Acer saccharum*, *Corticium vellereum* occurred 70 times and so far exceeded any of the other 21 species from this host in number. Decay in budworm-killed spruce and associated balsam yielded 97 cultures of which 65 have been assigned to 19 named species.

Isolations from decay in *Picea glauca*, *Abies balsamea*, and *Populus tacamahaca* in northern Saskatchewan yielded only *Stereum sanguinolentum* from balsam, *Pholiota spectabilis* from poplar and six species from spruce.

Thirteen isolates from typical decays were shown to be haploid cultures belonging to 11 species, indicating that initiation of decay by the mycelium from a single spore is of fairly common occurrence.

Interfertility tests were used to verify the identifications of isolates of *Fomes roseus*, *F. subroseus*, *Polyporus adustus*, *P. versicolor*, *Poria monticola*, and *Trametes serialis*. Additional interfertility studies on *Peniophora mutata* and *P. Allescheri* showed partial fertility between certain isolates, indicating that these belong to one species probably consisting of two or more races, and that *P. Allescheri* should be reduced to synonymy under *P. mutata*. Pairings in all possible combinations of a series of 17 monosporous mycelia of *Poria albipellucida* showed that the fungus is heterothallic and of the bipolar type of interfertility. Attempts to produce diploidization of a haploid colony by a suitable diploid mycelium (the "Buller Phenomenon") were made with eight species of Polyporaceae. The results ranged from no extension of diploid mycelium, through formation of sectors of varying sizes in which diploid mycelium occurred, to the diploidization of the whole haploid colony. These erratic results preclude the use of this technique for the corroboration of tentative identifications of diploid cultures by planting them on the periphery of colonies of named haploid cultures.

*Birch Die-back.*—Investigations on the die-back of yellow and white birch in the Maritime Provinces were continued in Pictou and Inverness counties in co-operation with the Nova Scotia Department of Lands and Forests and in New Brunswick in Albert county and at Fredericton.

Three phases of the problem were studied: (1) the possible role of the bronze birch borer in initiating the disease, (2) the relationship of root condition and crown symptoms, and (3) the importance of fungi associated with die-back.

Analyses of selected yellow birch trees in various stages of die-back for borer content included 27 trees in Inverness county and 14 trees in Pictou county. The results corroborated the conclusions of 1947, namely, that the early stages of the disease appear independent of the bronze birch borer attack.

Excavations of the root systems of 26 trees in Inverness county, 4 trees in Pictou county, and 18 seedlings at Fredericton were made. The results indicate that mortality of a portion of the feeding rootlets precedes twig mortality in the crown and that the percentage of dead rootlets increases with the degree of crown injury. The cause of the rootlet mortality is not known, but it is suggested that, because of the shallow rooting habit of birch species, even a minor decrease in precipitation might produce drought injury to the root system.

Numerous isolations from both living and dead tissues of trees affected with die-back were made for possible pathogenic fungi. The most commonly isolated fungi were *Phomopsis* sp., *Melanconis nigrospora* (Pk.) Wehm., *Melanconium* sp., and *Prosthemium* spp. Of these, *Phomopsis* sp. appeared most consistently and was used to inoculate healthy trees to determine its pathogenic capabilities. Limited infection was obtained when mycelial cultures were used as inoculum in

wounds but not when a spore suspension was used. Inoculations on trees previously weakened by wounding or root-pruning were made, but the effect of predisposition of the host in this manner must await later observation.

*New Quarters for Toronto Laboratory.*—In 1947, a forest pathology unit was established in Toronto to serve the forest interests of Ontario. Increases in personnel, required to meet the demand for investigations essential to proper forest practice and management, soon made larger and more suitable working space necessary. In October, 1948, the unit moved from crowded quarters at the Department of Botany, University of Toronto, to quarters in downtown Toronto. Some 6,500 square feet of floor space was acquired at 144 Front Street, West.

Projects begun in 1947 were expanded and new undertakings were initiated. The research programs were chiefly concerned with the growth and management of white pine, maple, spruce, and balsam fir.

*White Pine Blister Rust in Ontario.*—Losses due to the effects of white pine blister rust have concerned forest authorities for some time. Surveys made during 1947 broadly outlined the extent of the disease in the white pine stands of the Ottawa Valley and northeastern Ontario. It was demonstrated that from 15 to 20 per cent of trees of merchantable size in the age-groups represented are now fatally infected with this disease. Investigations conducted during 1948 were directed towards the formulation of pathological recommendations for the management of white pine stands. A recognition of the value of white pine in the Ottawa Valley and of the potential damage that might result from blister rust led the Dominion Forest Service to seek pathological information before embarking on an intensive program for the eradication of the alternate host of the disease. Systematic surveys were conducted in two compartments of the Petawawa Forest Reserve. Here, white pine is the most important tree species and these areas were considered as areas for eradication work. It was found that the percentages of trees infected with blister rust in the two compartments were 2.1 and 3.4, and that seedling growth was practically free of infection. Thus, although the compartments carried an above-average stand, the incidence of disease was insufficient to warrant additional expenditures for a general eradication program. The previous eradication work may be the important factor in reducing the amount of blister rust in these areas. As a check, a survey will be undertaken in similar stands which never have been given any protection from this disease.

Other longer term investigations are being emphasized to determine the rate of development of trunk cankers and their effect on increment in diseased trees. These investigations will be valuable in the formulation of pathological recommendations for rotations and management plans for white pine.

An interim report on these phases of blister rust has been distributed to forest authorities and to industry.

*Decays of White Pine.*—At present, the major part of the commercial cutting of white pine in Ontario is located in over-mature stands. These stands have been reported to contain trees with abnormal volumes of defect, and a number of requests have been received from the logging industry and from the Ontario Department of Lands and Forests for information about the decay losses of white pine. Pathological investigations were regarded as a matter of urgency in relation to present recovery of timber as well as to a long-term policy. It was felt that over-mature stands would be exhausted before younger stands matured, which demonstrates the immediate necessity for this research.

During the field seasons of 1947 and 1948, sample plot work was conducted in four pine areas in the Ottawa Valley and at Lake Temagami. Pine trees, numbering 1,012 in ten quarter-acre plots, were felled, dissected, and examined

for defect. Of these trees approximately 52 per cent contained decay. The proportion of trees with decay increased from 40 per cent at 60 years to 100 per cent at 200 years of age and a well-defined age-decay relationship was exhibited. Though actual losses in merchantable volume are small at 60 years of age, at 200 years the average gross volume is reduced by 40 per cent. Returns were computed in board-foot and cubic-foot volumes and tentative pathological rotations established. Tables to fix cull allowances for different age-classes were constructed as an aid to operators in determining the net volume obtainable in their operational areas. No well-defined relationship occurred between decay and diameter. The decay volume in slow-growing trees was appreciably greater than that in fast-growing trees.

Fourteen fungi responsible for the decays of white pine were identified. Of these, *Fomes Pini* (Thore) Lloyd was responsible for 88 per cent of the loss through decay.

An interim report of these findings was prepared for distribution to forest authorities and the industry.

*White Pine Needle Blight.*—This condition appears on white pines of all ages in Ontario and may kill all foliage of the current year. The cause of the injury is unknown.

During the year, 3,332 white pine trees in 32 sample plots were placed under observation in the Petawawa Forest Reserve. Various sites and age classes were included. These trees will be examined annually to determine the effect of needle blight on increment. Six additional areas were established to study the effect of needle blight on seedlings.

A preliminary classification of the sample plots into moist, medium, and dry sites demonstrated an appreciable difference in intensity of blight on these different sites. The average percentage of blighted trees on moist sites was 5.9, on medium sites 12.9, and on dry sites 25.9 per cent.

Further studies are in progress to determine the extent of damage from needle blight as reflected in reduction of growth rate and mortality, to analyse any abnormality and to test the effect of fertilization and irrigation practices. The preliminary findings have been summarized in report form for distribution.

*Decays of Maple.*—A considerable percentage of the forested areas of the Ottawa-Huron region of Ontario is comprised of stands of tolerant hardwoods. These stands in many instances were originally of a pine type. Management plans directed towards the conversion of inferior hardwood stands to softwood stands and the best utilization of existing types are now being made for the University of Toronto Forest in this region. Numerous requests for information about the most prominent tolerant hardwood, hard maple, were received by the Forest Pathology Unit in Toronto. Pathological information for this species was not available. An investigation was begun in 1947 and continued through 1948. Data obtained are being compiled to show gross and merchantable recovery from sawlogs and from fuel wood. The data will be analysed to show relationships between decay and age, diameter, and rate of growth. Pathological rotations for saw timber and for fuel wood will be prepared. Six local volume tables have been prepared and issued to interested authorities for inclusion in their management plans.

*Decays of Spruce and Balsam Fir.*—In co-operation with pathologists of the United States Department of Agriculture, a study was undertaken in 1948 to determine the decay losses in balsam fir and spruce. This work was conducted concurrently with a deterioration study carried on by the American pathologists in budworm-killed timber. The analyses of approximately 1,300 residual spruce and balsam fir trees were obtained. The data are being examined to determine net merchantability in stands of different ages and on different sites.

*Diseases of Nurseries and Plantations.*—Studies on seedling and nursery diseases were initiated during the past year. Included were investigations pertaining to losses due to blister rust, damping-off, and other troubles. Some control of damping-off was obtained through the use of various amounts of peat in seed-beds. Examination of the records obtained is proceeding and the development of a satisfactory control through cultural methods derived from these studies appears promising.

*Prairie Provinces Unit.*—This laboratory has now been established at Saskatoon. Temporary accommodation is being provided by the National Research Council.

*Heart-Rot of Spruce.*—This disease is considered to be the most urgent problem demanding attention in the forests of the Prairie Provinces. In this region white spruce (*Picea glauca*) attains its optimum development. While the once extensive, mature and over-mature virgin stands of spruce are rapidly approaching depletion through utilization, they are being replaced by younger stands ranging from seedlings to sawlog-size trees. As the trees approach merchantable age, the attacks of heart-rot fungi take an accelerating toll. In addition to the decreased value of the trees that are cut for sawlogs, there is the more insidious and probably much greater loss caused by wind breakage of trees that have been weakened by butt-rot. For the purpose of forest management, it is necessary to estimate, not only the percentage of decay that may be present in any stand marked for harvesting, but also the probable condition of any stand at any future age. To obtain a basis for such estimations is the object of this project. A number of sample plots was analysed in 1948 in the Dore Lake region. The project is to be continued until a complete range of site and age classes has been studied. In anticipation of conducting similar studies in other tree species, such of these as occur on the sample plots are being analysed in conjunction with the work on spruce.

*Resistance to Rust in Poplar Tree Breeding Stock.*—Poplar rust (*Melampsora medusae* Thüm.) may cause serious loss in forest nurseries and young plantations. The results of seven years of observations on 608 lots of experimental breeding stock have been summarized and presented to the Sub-committee on Tree Breeding of the National Research Council. A wide range of resistance was noted, from complete immunity to severe attacks causing midsummer defoliation.

*Decay in Western Hemlock, True Fir, White Spruce, Black Cottonwood, and Douglas Fir.*—During 1948, major emphasis was placed on studies relating to the management of mature and over-mature forests in British Columbia. Recent amendments to the Forest Act of British Columbia relative to sustained yield production have emphasized the importance of studies of this nature.

Two regional studies of decay were completed during 1948 and are being prepared for publication. These studies involved the analyses of decay in western hemlock on the Queen Charlotte Islands and in western hemlock and true fir in the Franklin River district on the west coast of Vancouver Island. Information has been obtained in each of these regions which is considered basic to the adequate appreciation and interpretation of forest management principles. Accordingly, it is considered that closer inventory, utilization, and management of these species will now be possible in the regions under consideration.

Further studies were undertaken in the case of white spruce in the Upper Fraser region, black cottonwood in the Quesnel area, and Douglas fir on Vancouver Island. Basic decay information relative to these important forest species is essential to continued forest production since the problems arising from decay losses have been shown to be of major importance in management and economic utilization. Additional samples of 272, 160, and 534 trees have been obtained in

the case of spruce, cottonwood, and Douglas fir respectively. Further analyses will be required in order to provide a sufficient basis for the reliable application of the data obtained.

*Pathology of Second-Growth Stands.*—During the past year, there has been an increased interest on the part of the forest industry in studies relating to the diseases of second-growth stands, since it is now recognized that sustained production in the future will be dependent upon a high volume production in the present immature forests. The British Columbia Forest Service has indicated the desirability of initiating co-operative studies in stands of this nature in order that disease mortality records may be related to predictions of future growth and yield. Co-operative studies of this nature were initiated during 1948 and a preliminary examination was made of 9 plots on Vancouver Island. The excessive mortality losses observed in some areas has indicated the need of more intensive disease studies in stands of this nature.

*White Pine Blister Rust in British Columbia.*—Extensive surveys were conducted in the Garibaldi region on the mainland coast of British Columbia in an effort to isolate strains of white pine resistant to the virulent blister rust which threatens the existence of this important tree species in the new forest. The successful establishment of blister rust in the Garibaldi region provided a suitable location for studies of this nature. In addition, the high mortality in white pine served to eliminate the possibility of disease-free pine representing disease-escape rather than disease-resistant individuals. A total cruise of 65 acres yielded 26 pine, tentatively classed as disease free. Nursery studies are planned to determine if these trees are capable of withstanding blister rust attack under conditions conducive to a high degree of infection.

A study of blister rust was conducted in the Mount Revelstoke National Park at the request of the National Parks Service. After a detailed analysis of the situation, it was concluded that direct blister rust control by eradication of the alternate host would not be practicable in this region. In view of the high aesthetic values in the Park, however, it was recommended that the present dead trees be removed and replaced by other species already established in the areas. This procedure would serve to reduce the direct costs of control and would result in an immediate improvement of the present stand.

*Deterioration Study.*—Preliminary studies were initiated in insect-killed western hemlock stands on lower Vancouver Island. Since a large percentage of this killing has taken place in stands that were to be held in reserve for future cutting, a drastic change in the management policy for this region has been necessary. The major problem which now confronts the logging industry is that of determining the maximum period during which decay and other losses will permit economical salvage. In order to provide this information, representative areas have been set aside for analysis over the next 3 to 5 years. A preliminary analysis of the disease situation in the stands at the present time has shown that 98 per cent of the dead trees are infected with decay that has entered subsequent to the death of the tree. The progressive rate of development of these initial infections will be determined through future analysis in order to obtain information relative to the maximum salvable period.

## Mycology and Miscellaneous Projects

*Plant Disease Survey.*—The Annual Report of the Canadian Plant Disease Survey for 1947 was prepared and published during the year.

The Report for 1948 is now in the course of preparation. A brief digest of the more important items is included here.

Unusually moist soil conditions and cool weather early in the season across Canada favoured the development of many diseases, such as late blight of potato, downy mildew of onion, leaf rust of wheat, and apple scab. In British Columbia, Nova Scotia, and the more northerly sections of several other provinces losses were heavy. Elsewhere the weather turned dry or was at least favourable for spraying or dusting operations; in consequence such controllable diseases caused only minor losses.

Only a trace of stem rust (*Puccinia graminis*) developed on the resistant wheat varieties universally grown in the 'rust area' in Manitoba and eastern Saskatchewan, whereas susceptible wheats included in test plots were heavily infected. Elsewhere stem rust was severe only on some late-maturing fields of soft spring wheat in southern Alberta. Leaf rust (*P. triticina*) infection was heavy on wheat throughout Canada except in parts of Saskatchewan and Alberta, but at most points the rust reached its maximum intensity only late in the season. Although oat stem rust and oat crown rust (*P. coronata*) were of little importance in Canada in 1948, it is impossible to escape the conviction that such sporadic outbreaks as do occur arise from the presence of the respective alternate hosts of these rusts.

Dwarf bunt (?race of *Tilletia caries*) was found well established but not severe in a small area in the North Okanagan, as a result of a special search in the principal wheat-growing districts of British Columbia. Dwarf bunt is difficult to control on account of its soil-borne habit. However, resistant varieties have been developed which can be grown successfully in British Columbia. Its introduction into Ontario would be much more serious because suitable resistant varieties are not available.

Flax rust (*Melampsora Lini*) followed by stem rot was epidemic in southern Manitoba and southeastern Saskatchewan and caused damage estimated at $9,000,000. Under the unusual weather conditions prevailing in 1948, the variety Royal, which has been commonly grown since 1942 because it possesses considerable mature plant resistance, was severely damaged. Pasmo (*Septoria linicola*) did little damage in 1948 but the disease is spreading and may be expected to become more prevalent.

Late blight (*Phytophthora infestans*) of potato caused severe damage in British Columbia, even penetrating many of the dry areas of the interior. The disease was widespread in Manitoba and eastern Saskatchewan and caused considerable tuber rot in northern areas. An epidemic was anticipated in Ontario, Quebec, and New Brunswick, but dry weather checked the disease or made possible the protection of the crop with fungicides. Late blight was destructive in Nova Scotia, especially in the coastal areas, but, although an epidemic developed in Prince Edward Island, the crop there suffered only a slight reduction in yield due to early destruction of the vines. Bacterial ring rot (*Corynebacterium sepedonicum*) continues to be very prevalent in table stock potatoes in Quebec and it is now evident that a similar situation exists in Manitoba. Furthermore, its high incidence in table stock seriously jeopardizes the production of seed potatoes in these provinces. In fact, ring rot is so prevalent in Quebec that there the disease is more prevalent in seed stock than it is in table stock in Alberta. Provincial action has kept ring rot virtually excluded from Prince Edward Island and British Columbia and has greatly reduced its incidence in Ontario, and particularly in Alberta, where the disease once reached alarming proportions. Leak (*Pythium ultimum*), long recognized as a troublesome decay of potatoes in transit to the early market, may apparently cause some damage to potatoes during the early storage period in a warm fall.

Root-rot (*Aphanomyces euteiches*) caused the loss of nearly 500 acres of late-maturing canning peas in Essex county, Ont. This disease has not previously been reported in Canada.

Apple scab (*Venturia inaequalis*) was very severe throughout British Columbia, but caused less injury than usual in Ontario and Quebec. Losses were also heavy in New Brunswick and Nova Scotia. Pear scab (*V. pirina*) was also severe and powdery mildew (*Podosphaera leucotricha*) of apple was more destructive than usual in British Columbia. Red stele (*Phytophthora Fragariae*) of strawberry, previously only known from British Columbia, is now known to be well established in Nova Scotia.

*Mycological Herbarium.*—In 1948, 1,611 specimens were added to the general herbarium, i.e., exclusive of mushrooms and wood-destroying fungi. Of this total, 600 were purchased, 537 were received in exchange, and the remainder were sent in for identification or were collected by members of the Division.

*Mycological Studies.*—Collecting of parasitic fungi in the Ottawa district had again to be relegated to a holiday undertaking; twelve new records for the district were secured. Parasitic fungi from various districts included eight new to Canada and several new to Ontario. A start has been made in the study of several groups of fungi from northern Canada.

*Variation in Fusarium.*—Studies on variation in the genus *Fusarium* have included determinations of the radial growth of cultures of *F. graminearum* on plates of potato-sucrose agar at 26°C. There was a wide variation in the rate of growth of 24 strains tested. In general, mutant strains grew more slowly than "wild type" cultures freshly isolated from nature. Strains with abundant aerial mycelium and few conidia usually grew more rapidly than those with sparse aerial mycelium and abundant conidia. Seventeen strains of *F. graminearum* were found to be viable after storage for one year in tubes of sterile soil, whether kept in the laboratory or out-of-doors. The same strains, when stored in tubes of unsterile soil in the laboratory, failed to survive for a year, and 12 of the 17 strains were recovered with some difficulty from tubes of unsterile soil kept out-of-doors for a year. The higher incidence of survival in unsterile soil out-of-doors is attributed to the unfavourable effect of freezing temperatures on the antibiotic activity of other organisms present in the soil.

## Diseases of Cereals

*Cereal Rusts.*—Surveys made in 1948 have revealed definite changes in the relative prevalence in Canada of races of stem and of leaf rust of wheat. Race 56 of stem rust continues to be the predominant race. In 1948, a marked increase in the prevalence of race 17 was in evidence. There was also a notable increase, particularly in the Prairie Provinces, in the abundance of race 38, which hitherto had been found chiefly in Eastern Canada. These changes in racial distribution do not affect the reactions of the stem-rust-resistant wheats now grown in Canada, but they may account for a somewhat increased rust development on barley. In leaf rust of wheat, there was a further slight increase in races 5, 15, and 126, which for several years have produced heavy infections on Renown, Regent, and Redman. In 1948, 90 per cent of the leaf rust collected on these varieties belonged to these three races. There has recently been a marked decrease in the prevalence of race 128, the race that had accounted for much of the leaf rust on these wheats from 1944 to 1946.

Owing to the frequent occurrence of the aecial stage of crown rust on buckthorn in Eastern Canada, a study was made of the rust derived from aecia collected in the eastern provinces on common buckthorn (*Rhamnus cathartica*) and alder buckthorn (*R. Frangula*). The rust variety *Avenae*, which attacks oats, was the most prevalent on the common buckthorn, but there were present on buckthorn also the varieties *Bromi* and *Festucae*. The latter variety, which attacks fescue grasses, had never before been found on buckthorn in Canada.

Infection studies with variety *Bromi* have shown that it can attack not only certain brome grasses, but also several species of wheat grass (*Agropyron*) and some varieties of rye and barley. On alder buckthorn, only the rust variety *Agrostis*, which attacks red top grass, was collected. This is the first report of the occurrence in North America of rust on the alder buckthorn.

Although the varieties of wheat now being grown in the rust area of Western Canada have so far proved to be resistant to the prevailing races of stem rust, it is known that they are susceptible to a race of this rust that has been found both in the United States and Canada in recent years. None of these varieties possesses a high degree of leaf-rust resistance and some are extremely susceptible. It is desirable, therefore, that the wheats in production at the present time should be improved in respect of both leaf- and stem-rust resistance. This program of improvement, which is now under way, necessitates the continuance of physiologic race surveys throughout Canada.

*Smuts of Cereals.*—A seed-drill survey was made in Manitoba in co-operation with the Provincial Extension Service. The study required the collection of samples of barley and oats from farmers' seed-drills, their examination for the presence of smut spores, and a subsequent inspection of the crops grown from the different lots of seed. An examination of the 307 seed samples collected revealed that none was entirely free from smut. Approximately 53 per cent of the samples had a trace of smut spores and the remainder carried light to heavy spore loads. Crops grown from seed bearing a trace of spores contained an average of 0.7 per cent smutted plants, exclusive of the loose smut of barley, as compared with 4.0 per cent in those grown from light to heavily smutted seed. The average percentage of smut in fields sown with seed that had received no treatment was 2.7. In fields sown with seed treated with Ceresan, Leytosan, or formaldehyde, the percentages of smut were, respectively, 0.3, 2.3, and 3.2.

That the cereal smuts are still responsible for appreciable crop losses in Manitoba is shown by reports of surveys made in 1948. The average percentage of smut in barley, including loose smut, was estimated to be 5.8, in oats 1.1, and in wheat 0.7. This represented, at prevailing prices, a loss of some $4,000,000, if reduction in yield of grain alone is considered.

Investigations, having as their objective the identification of races of the cereal smuts present in Canada, were continued at Winnipeg. The results of these investigations will facilitate the development of varieties of cereals possessing resistance to the prevailing races of smut, and thereby contribute to the reduction of smut losses. During the last year, 271 collections of cereal smuts were subjected to identification tests on a series of different varieties.

A large number of unnamed varieties of cereals, as well as many hybrids, were tested for resistance to different races of smut. These tests show that, of the varieties of hard red spring wheat presently grown in Western Canada, Redman is the most highly resistant to the prevailing races of bunt while Thatcher is highly resistant to the races of loose smut. Garry and Fortune oats proved to be resistant to the prevailing races of oat smuts. All of the commonly grown varieties of barley are susceptible to one or more of the barley smuts.

Oat seed infected with smut was treated at Ottawa with 12 different fungicides and tested in the field. Excellent control was obtained with Arasan and R118A, and good control with Leytosan, Phygon, Tersan, Zerlate, Panogen, Fermate and Spergon, in descending order of effectiveness.

Studies on the hot water method for the control of true loose smut in barley indicated that Saskatchewan barleys were severely injured by the ordinary methods. As the injury appeared to be related to the high treatment temperature, investigations were directed towards devising a more suitable treatment procedure. Fairly good results were obtained by using a somewhat lower temperature and a modification of the pre-soaking schedule. Seed of three

barley varieties, Plush, Vantage, and Newal, was tested after a six-hour pre-soaking at water temperatures from 120° to 130°F. Vantage was severely injured at temperatures above 124°F. The other varieties showed severe injury above 126°F. The influence of the length of time that the seed is kept in the water bath was studied. The temperature of the water was kept at 126°F. Although some variation in the behavior of different samples of barley occurred, on the average, there was a regular increase in injury from 5 to 20 minutes. The average germination after treatment for 5 minutes was 90 per cent and after 20 minutes it was 20 per cent. Another sample of barley, which had been mechanically injured in threshing and therefore sensitive to heat injury, was treated at temperatures of 118°, 120° 122°, and 124°F. Considerable injury was evident at all temperatures. A temperature of 118° F. gave very little reduction in smut, but temperatures of 122° and 124° controlled it completely. Field experiments in general confirmed the greenhouse findings; good control of loose smut in barley was obtained with a temperature of 124° F. and reasonably good control at 122° F., although there was a slight reduction in yield. For most barley varieties an exposure of 11 minutes at 126° F. after proper pre-soaking is recommended.

*Root Diseases.*—Experiments made at a number of stations in Western Canada have shown that several of the new hard red spring wheat hybrids are more resistant to root-rot than the commonly grown varieties, although less resistant than McMurachy's Selection, a variety that has proved to be highly resistant in extensive tests conducted over a period of several years. None of the new durum wheat hybrids tested was superior in root-rot resistance to the varieties now being grown. One new oat hybrid (R.L. 1492) was found to be highly resistant to root-rot.

In earlier work on the resistance of cereals to *Helminthosporium sativum* at Saskatoon, it was shown that seed had to be disinfected previous to inoculation to rid the surface of any antibiotic bacteria. At first, formalin solutions were used for disinfection but later tests showed that the addition of lactic acid to the solution increased its effectiveness. These inoculation tests revealed the close relationship between seed carrying abundant bacteria and freedom from lesions. When the bacteria were removed, infections increased. Fourteen wheat varieties and selections, including some foreign varieties, were tested against *H. sativum* in a series of experiments. All of the varieties showed fair resistance in comparison with Marquis and Reward. From these Florence Selection, Sevier, and Blue Chaff were selected for further trials in comparison with Thatcher and Reward. Disease rates obtained were as follows: Blue Chaff 13, Sevier 14, Florence Selection 20, Thatcher 53, and Reward 89. With the new technique of surface disinfection, several Kenya wheat selections, which previously had shown some resistance, were retested. One selection, Kenya 12, was found to be very resistant in comparison with Marquis and Reward. Sixty-two lines selected from a cross between Kenya 9 and Marquis were tested for resistance. Four lines classed as resistant and four classed as susceptible were tested again after surface disinfection. The difference between the two groups tended to disappear when the antibiotic flora was removed by surface disinfection. Thirty-seven lines from a cross between Kenya 8 and Rival were tested for resistance. They revealed degrees of susceptibility from moderate to very susceptible.

The annual testing in naturally infested field plot soil of varieties and hybrids of wheat for resistance to root-rotting fungi was continued at Edmonton. Of 38 varieties tested, Propo, McMurachy's Selection, and some others possessed resistance, whereas Idaed, Regent, and Lemhi were quite susceptible.

In search of a quick laboratory method for detecting natural resistance in different cereal varieties and hybrids to root-rotting pathogens, manometric determinations of the catalase content of various varieties of wheat seedlings

have given encouraging results; a high catalase content appears to be commonly associated with disease resistance.

In the field surveys in Saskatchewan particular attention was given to root diseases. Some 362 fields were examined; 245 were of wheat, 45 of barley, and 72 of oats. Common root-rot was found in all wheat fields surveyed and infection was somewhat higher than last year. In the southwest, there appears to have been an increase in the incidence of common root-rot during recent dry years since 1943; in that year the infection rating was 8.5, whereas in 1948 it was 17.8. Common root-rot was found in most barley fields, some of which were severely infected. The disease was present in most oat fields, but it caused little damage. Only a few rye fields were surveyed and severe infections were observed in some. There were indications that common root-rot might be a serious disease of rye under suitable conditions. Other root diseases were of minor importance.

A large number of isolates of *H. sativum* were tested for their pathogenicity on wheat varieties. Fifty-five isolates were used to inoculate Marquis and Reward wheats in the first series of tests and practically all were found to be virulent. A few isolates varied in virulence from test to test. Experiments to determine the influence on virulence when cultures were maintained on artificial media or periodically passed through the host were inconclusive. Subsequent tests included a number of representative varieties of wheat inoculated with eighteen different isolates of *H. sativum*. No significant interaction between varieties and isolates was found. It appears, therefore, that any moderately pathogenic isolate may be used in comparing varieties for resistance.

Studies were made on the relationship between the occurrence of *H. sativum* on stubble and in soil and the onset of primary infections. A technique was devised to detect conidia in soil samples. Preliminary work with various samples indicated the wide distribution of conidia in field soil. Viability tests showed that such conidia were viable after long periods in either dry or moist soil. Soils vary in their antibiotic influence on *H. sativum* development; however, some soils to which conidia of this fungus were added maintained a high degree of infectivity when wheat seeds were planted in them. This finding strongly suggested that free conidia in the soil are a good source of primary infection. Inoculation tests in which wheat was inoculated by a conidial suspension over the surface of the soil were very successful. Inoculation could be made before or after emergence. In nature, the soil would be supplied with an abundance of conidia produced on infected plant parts or stubble throughout the fall, spring, and summer.

One phase of the cereal root disease problem investigated in 1948 at Saskatoon has been an intensive study of isolates of the prevalent pathogen, *Helminthosporium sativum*. The isolates were investigated for cultural and other characteristics while, at the same time, special efforts were made to determine their genetic reaction through mating studies. Fifty-six isolates of single conidia, mostly from wheat collected at various points in Saskatchewan, were used. These cultures were mated in all possible combinations. Different media were employed including sterilized straws of cereals and grasses. After some preliminary work in which perithecium-like bodies were observed, it was soon possible to select fertile pairs which upon mating produced perfect perithecia. The same or a similar ascomycete was reported from Japan in 1929 and India in 1942. A taxonomic study of the organism indicated that the fungus is *Cochliobolus sativus*. With the perfect stage of *H. sativum* now available, rapid progress can be made in determining the genetic variability of the pathogen.

The proportion of isolates of *Helminthosporium sativum* to *Fusarium culmorum* obtained at Edmonton from the crowns of winter wheat was 1 to 3 in the specimens collected from southern Alberta, and 1 to 13 in those from the Peace River area. Tests made in the greenhouse showed that a high percentage

of the *Fusarium* isolates from the Peace River area were highly pathogenic. Despite the prevalence of the two pathogens mentioned, *Ophiobolus graminis* continued to be the most important root-rotting pathogen of winter wheat in northern Alberta and in the foothills of southern Alberta.

Some of the common barley varieties were tested for resistance to *H. sativum*. The four most resistant varieties were Regal, Montcalm, Titan, and O.A.C. No. 21 and the four most susceptible were Newal, Olli, Trebi, and Rex.

Preliminary experiments were conducted to study the influence, on *H. sativum*, of seed treatment with Ceresan or Arasan, and of bacterization of the flora of the seed. Seed treated with Ceresan inhibited the fungus much more than seed treated with Arasan in laboratory tests. If, however, the seeds treated with these fungicides are covered with damp soil for a few hours, the strong inhibitory effect of Ceresan on *H. sativum* is lost while the influence of Arasan remained unaffected. In similar tests, seeds carrying bacteria antagonistic to *H. sativum* were unaffected by the soil. Ceresan strongly inhibited miscellaneous bacteria in an agar plate test while Arasan did not. When the treated seed, however, was covered with soil, the inhibitory influence of Ceresan on the bacteria was lost and treatment with Arasan was unaffected. In a greenhouse pot test with wheat in which the soil was heavily infected with *H. sativum*, Ceresan treatment gave the best protection, Arasan next, and bacterization was unsatisfactory.

The results of field plot experiments made at Winnipeg in 1947 to determine the effect on yield of treating wheat seed with Ceresan dust were confirmed by further experiments conducted in 1948. The yield from high quality seed of Regent wheat was not improved significantly by treatment, but the yield from seed having a considerable proportion of the kernels affected by the seedling blight organism, *Helminthosporium sativum*, but otherwise of good quality, was greatly increased by treatment. The yielding capacity of defective seed when treated was equal to that of high quality seed. Similar experiments made with wheat, oats, barley, and flax indicated that seed treatment may be expected to bring about greater increases in yield when crops are sown on weedy land than on clean land.

The new Helminthosporium blight of oats caused severe damage to several fields of Garry oats in Manitoba in 1948. Of the samples of oat seed from different parts of Canada examined for spores of the causal fungus, relatively few were found to be infected and these were confined to seed of susceptible varieties.

Seed of Beacon oats naturally infected with *Helminthosporium victoriae* was treated at Ottawa with 14 fungicides, stored for 7 months, and planted in the field. Best control was obtained with Ceresan, Panogen, and R118A. To determine the effect of post-treatment storage, seed of Beacon oats naturally infected with *H. victoriae* was treated with 14 fungicides, stored for intervals of from 2 days to 7 months, and plated on malt agar. The length of the period of storage, at least up to 7 months, did not significantly affect the incidence of disease. Best disease control was obtained with Ceresan, R118A, and Panogen.

Panogen treatment at the rate of 1½ oz. per bushel and a storage period of 7 weeks gave good control in Montcalm barley infected with *Helminthosporium sativum* in field tests. Regent wheat infected with *H. sativum* was treated with Panogen at the rate of 1½ oz. per bushel, stored for 5 weeks, and plated on malt agar. Only partially effective disease control was found.

*Testing the Efficiency of Seed-Treating Machinery.*—A test to determine the efficiency of two seed-treating machines, the Panogen Seed Treater and the Siren Seed Treater, was conducted at Ottawa. The test is primarily concerned with the uniformity and completeness of fungicidal coverage. The Panogen

machine did not give wholly satisfactory results, and it is suggested that further tests with this equipment be made. The Siren machine, which is still in the process of development, is not considered suitable at present.

## Diseases of Forage, Fibre, and Oil Crops

*Diseases of Alfalfa.*—Extensive field plot tests for natural resistance in alfalfa to winter crown-rot in varieties, in promising selections, and in hybrids originating from promising selections, were continued at Edmonton. Present indications are that some progress is being made in securing greater resistance. The plant breeding aspect is carried on by the Forage Crops Laboratory, Saskatoon. Field surveys have shown that winter crown-rot in alfalfa continues to be of major importance in central and northern Alberta.

To study satisfactorily the resistance of alfalfa to the winter crown-rot, it was necessary to establish a disease plot at Saskatoon. Inoculum was prepared and applied to the selected plot by broadcasting, spot inoculation, and row inoculation. The broadcasting method was very successful if rain or snow followed, but dry conditions kill or inactivate the inoculum. The spot method proved successful if the inoculum was placed against the crown. The row method was reasonably successful, but in most respects the other methods were superior. The experiments showed that a plot for testing the resistance of alfalfa to winter crown-rot could be established at Saskatoon.

During the season of 1947-48, the application of borax in a spray to alfalfa foliage during September gave a promising degree of control of winter crown-rot the following spring. Preliminary studies in the Edmonton laboratory have suggested that control is due to the absorption of the chemical by the foliage and not to any effect on the pathogen in the soil.

The annual survey of alfalfa fields in the general Edmonton area for evidence of the progress of bacterial wilt indicated that, while the disease is present in a number of fields, no serious increase seems likely under prevailing conditions.

In the 1947-48 alfalfa wilt test at Lethbridge, all the plants in 20 clonal lines and 12 seedling lines were free of bacterial wilt. These lines included several promising selections, one of which was also resistant to winter crown-rot. New lines were selected for testing, and several thousand plants were inoculated prior to transplanting and were re-inoculated by hypodermic injection in the fall. Bacterial wilt was very prevalent in irrigated alfalfa and developed to an unusual degree in young stands.

Alfalfa black stem (*Ascochyta imperfecta*) was prevalent in northeastern Saskatchewan in 1947. Isolations were made at Saskatoon from seed samples from 18 districts in this region and *A. imperfecta* was readily obtained from all samples, some samples showing up to 20 per cent of infected seed. Thus, the seed appears to be an important source of inoculum in the dissemination of the disease. When infected seeds germinate, the seedling tissues are invaded and the disease advances rapidly under moist conditions to kill the seedling. In an experiment in which the seeds were inoculated with a conidial suspension, the seeds were sown after inoculation on moist sterile soil, moist sand, and on moist filter paper. Heavy infection of the seedlings resulted in all cases, but it was particularly severe on the seedlings grown on filter paper. Experiments with fungicides, such as Ceresan, Semesan, Arasan, and Spergon, indicated good control of the seed-borne infection. Ceresan and Arasan were especially effective. In co-operation with the Division of Forage Plants, the breeding of alfalfa varieties resistant to black stem is in progress. A rapid method of testing seedlings was developed. To date, 40 hybrids and varieties have been tested, although very little resistance as yet has been detected.

A root-rot caused by *Phytophthora Cactorum* was found to be responsible for serious reductions in stands of sweet clover in Essex and Kent counties, Ont., in 1948. The disease was destructive from mid-April to mid-May, when 75 to 90 per cent of the stand was destroyed in some fields. The progress of the root-rot was checked as the season advanced, but plants with rotted roots could be found even in mid-summer. A *Fusarium* species was always associated with the late decay, but it appeared to be a secondary invader. After intensive search, Phytophthora root-rot was again observed in early November. Isolates of *P. Cactorum* from sweet clover grew particularly well on moist, sterilized rolled oats.

Sweet clover was shown to be susceptible to attack by *P. Cactorum* at all stages of growth, but the plant is probably least susceptible from three weeks to four or five months after emergence. The seedling blight phase was found to be severe in both sterilized and unsterilized soil infested with the fungus, but pre-emergence blight was much more severe in unsterilized soil while post-emergence blight was more severe in sterilized soil. Seedling blight was severe even in D236 and S-30-35-181, two sweet clover strains that have been reported to carry a high degree of resistance to Phytophthora root-rot as the plants approach maturity. The optimum temperature for the growth of *P. Cactorum* is about 18°C. Both seedling blight and root-rot caused by this fungus were more severe at 20°C. or lower.

*Diseases of Red Clover.*—The growing of Altaswede red clover for hay and seed is now extensive in Alberta, and surveys of the crop show that a disease caused by *Kabatiella caulivora* commonly destroys the pedicels of the flowers. Laboratory studies have been made to discover a suitable method of securing artificial infection of plants in field tests for varietal resistance. The resistance studies are carried on in co-operation with the Experimental Station, Lacombe.

*Diseases of Flax.*—Differences in virulence of *Colletotrichum linicola*, the causal agent of flax anthracnose, have been observed consistently on clay and sandy soils for the past few years in Quebec. The disease is usually quite severe on light sandy soils. In a search for an explanation of this phenomenon, it was observed that bacteria are abundant in clay soils while almost absent from sandy soils and that a high proportion of these organisms are antagonistic to *C. linicola*. The antagonism of these bacteria *in vitro* was expressed by an inhibition zone in which germination of spores was absent or restricted and abnormal. Four of the bacteria under test not only inhibited germination but killed the spores. The toxic substances produced by the bacteria, however, were not stable and none of the filtrates from liquid cultures inhibited spore germination and fungus growth.

The antagonism of these same bacteria to *Fusarium oxysporum* f. *Lini* was tested. Most of the species that were antagonistic to *C. linicola* behaved the same way towards *F. oxysporum* f. *Lini*, the four most antagonistic being the same for both organisms.

Seed of Royal flax naturally infected with *Alternaria linicola* was treated at Ottawa with Panogen at the rate of 4½ oz. per bushel and plated on malt agar. Although there was evidence of injury from over-dosage, disease control was inadequate.

*Sunflower Rust.*—Considerably more rust occurred on the sunflower crop in Manitoba in 1948 than in preceding years. In the Morden area where some 30,000 acres are planted to sunflowers, the hybrid variety Advance, which accounts for most of the acreage, was not appreciably affected by rust. The female parent of Advance, however, is highly susceptible to rust and in crossing blocks the yield of seed was seriously reduced. As a considerable acreage of the female parent must be grown to secure an adequate supply of Advance seed, the problem of controlling rust is of particular concern to seed producers. Until

rust-resistant varieties of sunflower have been developed it may be necessary to protect the female parent from rust infection by applying dusts or sprays. Experiments with this object in view have already been undertaken. Another disease of sunflowers that has caused serious losses in isolated fields is Sclerotinia wilt. A nursery has been started at Winnipeg to test the reaction of sunflower varieties and selections to this disease.

## Diseases of Fruits

*Apple Scab and its Control.*—The apple orchardists in Nova Scotia experienced adverse conditions during the early spray period in May and June. The heavy, power spray equipment bogged in the wet soils and made impossible timely applications of fungicides in many orchards. Frequent applications later protected much of the fruit from scab.

In a series of comparative tests of fungicides, the materials—Fungicide 341C, Flotation Sulphur, Fermate, and Phygon XL—gave better control of scab than dry wettable sulphur or mercurated lead arsenate. The first four fungicides named were about equally effective. At harvest, there was little or no red mite on the fruit sprayed with Fungicide 341C whereas the pest was present on fruit from the other plots.

A comparison of the eradicative value of fungicides, applied 1, 2, or 3 days after the beginning of an infection period by the apple scab fungus in a small plot experiment, revealed the usefulness of the organic mercury materials, Tag Fungicide HL331, and Puratized. Bioquin 1 and Phygon XL compared favourably with lime sulphur. Bordeaux showed little value except as a protectant. T.M.T.D. and Venturicide were unsatisfactory as eradicants.

Seven chemical substances were applied in varying concentrations as sprays to apple trees in the fall to study their effect on the development of perithecia of *Venturia inaequalis*. All treatments applied tended to reduce the number of perithecia formed on treated leaves. The reduction in number of perithecia formed varied from less than one per cent with one concentration of alpha naphthalene acetic acid to 73 per cent with one concentration of sodium pentachlorphenate. The suppressing effect by the chemicals tested was least with hormones of the alpha naphthalene acetic acid type, intermediate with mercurial fungicides, and greatest with selective herbicides.

In 1948, a season particularly favourable to apple scab development, three micronized forms of sulphur applied as sprays failed at Fredericton to control scab infection satisfactorily, when used in a continuous schedule. Two organic materials, Phygon XL and Glyoxalidine, proved fairly satisfactory in a similar schedule. Phygon XL, however, appeared to depress apple size, caused slight fruit russetting, and caused some injury to the leaves. An outstanding feature of the plot sprayed with Glyoxalidine was the complete absence of red mite eggs on the calyx ends of the apples.

Elemental microfine sulphurs at St. Catharines gave poor control of apple scab, particularly in comparison with the organic fungicides. Their ineffectiveness was attributed to low retentiveness of spray residues, failure to renew coverage after exposure to undue weathering, and the greater ability of the organic fungicides to check scab development following critical infection periods. It was quite apparent that satisfactory scab control with the sulphur fungicides in wet seasons requires additional applications and careful attention to their timing.

Of the seven microfine sulphur fungicides used in the experiment, Magnetic 70 sulphur paste proved the most adhesive and therefore the most effective. The spreader-adhesive materials, Orthex and p.e.p.s., were used to good advantage with the dry microfine sulphurs, greatly improving the control of scab although not to the extent required for commercial standards.

HL331, an organic mercury, gave outstanding control of scab. As a protectant, it appeared to persist very well and it also exhibited very definite eradicant properties. No evidence of significant injury to the trees was observed. The trees remained full of foliage, bearing large healthy leaves and fruit of good size and quality in striking contrast to trees sprayed with sulphur in which heavy infections had caused much leaf fall and seriously affected the size and grade of fruit. On the basis of one year's trial under severe disease conditions, this fungicide may be considered very promising for scab control.

Compound 341C and Phygon XL provided good commercial scab control. More foliage infection was present on the trees, although generally it developed quite late. The fruit, which remained very free of scab, was marred by an excessive amount of russet. Phygon XL was also found to be definitely toxic to the foliage. Injury was evident in the form of varied mottling of the leaves, yellowing, and drop. The injury was most marked following the later applications, when the temperatures were higher, and continued to appear throughout the remainder of the season. It was also observed that, where this material was used in 1947, the fruit crop was reduced.

Fermate was quite ineffective in preventing heavy foliage infection, but it afforded good protection to the fruit. This special value of Fermate in the cover sprays has been demonstrated in previous experiments.

The spray program employing Fermate and Phygon failed to prevent scab infection in Flemish Beauty pears.

The general purpose of the work on the control of apple scab by the Summerland laboratory is to establish the most satisfactory spray schedule in each district where this disease occurs. In the Salmon Arm district, an iron carbamate-wettable sulphur, three-spray schedule gave 97 per cent marketable fruit and a similar lime sulphur schedule 98.3 per cent. In Creston, a five-spray schedule gave with iron carbamate-wettable sulphur 93.6 per cent marketable fruit, with lime sulphur 92.9 per cent, and with wettable sulphur 66 per cent.

A control test with the new concentrate sprayer developed by the Division of Entomology was carried out in the Lavington district (comparable to Salmon Arm). In a four-spray schedule with lime sulphur and wettable sulphur, the hydraulic unit of the experimental sprayer gave 99.8 per cent marketable fruit, the steamer unit 99.8 per cent, and a conventional sprayer 100 per cent.

*Powdery Mildew of Apple and Pear.*—A large number of tests were made again at Summerland in an attempt to discover a satisfactory control for this disease, and none proved to be effective. In a life history study of the causal organism, it has been shown that the mycelium, which overwinters in the buds, is localized chiefly on the bud scales, the leaf hairs, and the tips of the embryonic leaves, during the dormant season. As growth begins again in the spring, it spreads rapidly over the developing leaves or floral parts and, by the time the bud breaks, the fungus may be sporulating freely. An attempt is being made to discover the time when the mycelium enters the buds. It has already been shown that the buds that produce the current season's growth may be infected by the middle of the previous season.

*Crown-Rot of Apple Trees.*—In the continuation of the work on this problem, 390 inoculations were made on materials from 25 apple varieties and 424 inoculations on materials from 5 pear varieties. The general results obtained to date indicate that, in apple, the variety Antonovka has the lowest disease rating, and, in pear, Old Home. Several other varieties have shown considerable promise.

*Virus Diseases of Stone Fruits.*—The viruses of prune dwarf, cherry yellows, tatter leaf of sweet cherry, and necrotic ring spot, each induced delayed foliation, etching and necrotic spotting, i.e., typical "shock" symptoms, in Montmorency cherry inoculated just before bud break. Significant reductions in total yield

of fruit over a 3-year period were noted in Montmorency cherry trees infected with either prune dwarf, tatter leaf, or cherry yellows. Lindner's chemical test for stone fruit viruses was found too variable to be entirely reliable for the diagnosis of virus diseases in Montmorency cherry.

Measurements of leaves of Montmorency and Napoleon cherry indicated that each virus had a more or less characteristic effect on leaf size and shape. Slight but definite modifications of the length-width ratio were detected in leaves of comparable length.

Orchard surveys showed substantial increases in the incidence of tatter leaf in sweet cherries and of both yellows and necrotic ring spot in sour cherries. Mottling of foliage, with and without ring patterns, was fairly prevalent in sweet cherry orchards. A few sweet cherry trees in one orchard showed a midsummer drop of yellow leaves bearing dark green, ring and line patterns; in another orchard, leaves on three trees were chloratic, dwarfed, and distorted, and bore severe necrotic spots. The cause of these abnormalities has not yet been determined.

The survey in the Okanagan Valley in connection with little-cherry disease was continued by the British Columbia Department of Agriculture, but no case of the disease was discovered. Some evidence was obtained to indicate that the wild cherry (*Prunus emarginata*) may be a symptomless carrier of little-cherry. A reconnaissance survey of the Okanagan Valley for this species indicates that it is present there, but it does not occur in the vicinity of the general cherry plantings in the southern part. In the study on insect vectors, none of the insects tested has as yet transmitted the disease. Good progress has been made in the development of an isolated 10-acre block in the Okanagan, where viruses occurring in the area will be studied.

*Brown Rot of Stone Fruits.*—Wet weather in the bloom period at St. Catharines favoured outbreaks of blossom blight in peaches, the severity of which varied with the variety. Blossom blight was reduced considerably by thorough spraying or dusting. On the other hand, there were indications that insufficient fungicide may, on occasions, be worse than none at all.

The summer and early fall were unusually dry, so that little brown rot was expected in the orchard. However, brown rot was plentiful where fruit had been injured by fruit moth. Uniformly favourable weather during harvest made it possible to demonstrate varietal differences in susceptibility to brown rot.

The use of stickers with sulphur sprays, of paste sulphur for cover sprays, and of extra sprays at critical periods, each greatly improved the control of brown rot in packs of peaches.

Pre-bloom and bloom applications of sprays with micronized sulphur, Magnetic 70 sulphur paste, and Phygon XL to cherry trees were effective in reducing losses due to brown-rot infection of the blossom parts. The paste sulphur applied at bloom under high humidity conditions caused extensive browning of the petals. This injury did not, however, appear to affect the set of fruit. The evidence obtained indicated that, under conditions favourable to brown rot, better control of the disease is secured by a pre-bloom spray followed by an application of sulphur dust in full bloom than by repeated sprays. Fruit set may be seriously reduced by heavy sulphur residues resulting from repeated dusting or spraying during bloom.

*Physiological Disorders of Stone Fruits.*—In studies on the boron content of tree tissues and the expression of deficiency or excess symptoms, it was shown that, when tissues contained less than 10 p.p.m. of boron, deficiency symptoms appeared and that, when more than 90 p.p.m. were present, excess symptoms were present.

*Diseases of Raspberry.*—Owing to a severe outbreak of anthracnose in the raspberry trial plots at the Experimental Station, Kentville, N.S., a delayed dormant spray of 1 per cent Dinitrosol, followed by an application of Fermate (2 lb. per 100 gal.) when the canes were 12 inches high, was used as a control measure. The results were satisfactory. The varieties Newburg and Viking were lightly affected by anthracnose; Ottawa was severely affected; and Washington, Taylor, Trent, and Gatineau were intermediate.

Excellent control of anthracnose on Taylor red raspberry was secured at St. Catharines by the application of Krenite at the delayed dormant bud stage, followed by a protective application of Fermate or Phygon XL on the current season's canes when they were 8 to 10 inches high. A second summer application, two weeks later, was without value.

The same schedule and fungicides reduced the amount and severity of spur blight. For this disease, the second summer application was found advisable to prevent blight lesions on the upper part of the canes and late suckers. The effectiveness of the treatment might be increased by delaying the time of application of both the delayed dormant and the summer applications. Phygon caused a superficial, but not extensive or important, scar russet on the current season's canes.

*Inspection and Certification.*—The annual inspection of raspberry plantings for certification of planting stock was carried out for nineteen growers in Ontario. Five plantings out of one hundred and three were rejected because of the incidence of virus disease. A list of fourteen growers with plantings meeting inspection requirements was prepared and made available for distribution. Certification tags sufficient for 510,000 canes were distributed to the growers. Thus, there was a large increase in the amount of stock available compared with the 1947 season.

*Diseases of Strawberry.*—The Kentville laboratory co-operated with the Nova Scotia Department of Agriculture and Marketing in a strawberry nursery stock improvement plan. Standard nursery plantings were inspected and rogued at least twice for virus-affected and off-type plants and clone plantings were visited three times during the season. The object has been to eliminate identifiable virus-carrying plants visibly affected by a virus disease. Plants will be inspected in the spring for red stele and root-rots.

In the course of a study of the strawberry leaf-spot fungus (*Mycosphœrella Fragariae*) at Ottawa, another leaf disease hitherto unreported in Canada, leaf blight (*Dendrophoma obscurans*), was found to be causing as much injury as leaf-spot or leaf-scorch (*Diplocarpon Earliana*), if not more. Leaf blight was also observed at St. Catharines and Park Hill, Ont.

During the last few years, the Marshall strawberry plantings in Washington have been deteriorating rapidly from "yellows" virus infection. The events in Washington have focused attention on the virus situation in strawberries in British Columbia. So far as is known, the present stock of British Sovereign, which is the only variety grown extensively in B.C., is free of visible virus. The question arose whether this stock was uninfected or was tolerant to the virus. Stolon grafts were made in late July between apparently healthy British Sovereign plants and Marshall plants showing severe yellows. The British Sovereign runner plants beyond the point of grafting showed signs of disease by September, and, by October, the parent plants were reacting, indicating that this variety is susceptible and that virus-free stock must be maintained.

*Diseases of Blueberry.*—A special survey of the principal wild blueberry growing areas in Prince Edward Island, New Brunswick, and Nova Scotia was made by the Kentville laboratory during the summer of 1948 to determine the pathological conditions causing economic loss. The two fungus diseases, red leaf

(*Exobasidium Vaccinii*) and witches' broom (*Calyptospora Goeppertiana*), were widespread and caused the total loss of fruit on affected plants. At least two leaf spots were found causing partial to complete defoliation in some districts. The organisms associated with the leaf spots are under study. Several other diseases were observed, some of which were causing losses of serious proportions in localized areas and will require investigation. The high-bush blueberry appears to be seriously affected by a die-back and canker (*Godronia Cassandrae*). Therefore, some hesitation is felt in regard to the establishing of new plantings.

*Diseases of Grapes.*—In a spray experiment to determine the relative importance of the recommended spray applications in the control of downy mildew, it was found that on Fredonia the pre-bloom application was important. Where this application was omitted, the incidence of disease was about equal to that of unsprayed vines and quite heavy loss of fruit clusters occurred. On Agawam and Delaware, the omission of this application had little influence on the amount of mildew.

Bordow and Phygon XL were less satisfactory fungicides in the control of downy mildew than was bordeaux either at the strength of 7½-10-100 or 5-5-100. A few vines sprayed with Phygon exhibited a blotchy mottling of the foliage. The berries, particularly on vines bordering plots sprayed with copper, showed severe russet markings. Orthex, spreader-adhesive, and p.e.p.s. adhesive, added to the bordeaux did not improve control on Fredonia.

*Chlorosis of Grape.*—Severely chlorotic Concord grape vines responded to treatments with 1 and 2 per cent iron sulphate solution applied as foliage sprays. Greening of leaves was first noted three days after spraying and the condition of the vines improved steadily. The vines remained green for the remainder of the season. Recovery was also obtained with manganese sulphate although the response was not consistent and recovery was less complete, the vines remaining a paler green than those treated with iron sulphate.

No beneficial result followed spraying with magnesium sulphate, ferric carbamate, or urea. The foliage on the vines remained distinctly yellow and showed extensive areas with severe scorch.

*Diseases of Currants.*—Spray treatments with Fermate, Bioquin 1, and T.M.T.D. have not shown any superiority over bordeaux mixture in the control of currant leaf-spot (*Mycosphaerella Grossulariae*). Though Fermate appeared to hold the disease in check early in the season, it did not prevent a late outbreak. None of the fungicides used gave control of cluster cup rust, white pine blister rust, or powdery mildew.

## Diseases of Potato

*Late Blight of Potato.*—Weather conditions in Prince Edward Island during the 1948 growing season were favourable to the development of a moderate epidemic of late blight of potato. The disease was observed on sprouts and young plants in a potato cull pile near Charlottetown, July 3, the earliest recorded date for its appearance in this province. Field infection was noted on July 26 and by August 20 many inadequately sprayed fields were dead or dying as a result of the very marked development of blight. Growers who followed the regular spray schedule kept the disease under control in their fields. Four copper fungicides were tested and were of approximately equal value in preventing foliage infection, bordeaux mixture and Bordow being slightly more effective than C.O.C.S., Niatox, and Deecop. On the other hand, great differences were exhibited by the four organic fungicides used in these experiments. Fungicide 629 was worthless, whereas Parzate and Phygon appeared very promising. Plots sprayed with C.O.C.S., Niatox, Bordow, and Parzate gave the highest

yields (over 290 bu. per acre). Those receiving bordeaux (4-2-40) were second with a yield of 275 bu. per acre, whereas those receiving Dithane, Deecop, and Phygon XL yielded around 250 bu. per acre. Over a 4-year period, the yield of plots treated with bordeaux mixture and Dithane was 290 and 275 bu. per acre, with a mean loss from late blight tuber rot of 0·5 and 3·4 per cent, respectively. Applications of the fungicides copper sulphate plus lime, copper oxychloride sulphate, and tetra copper calcium oxychloride were compared in a separate set of experiments. Each of these materials was applied in both dust and liquid form, the formulae and rates of application being calculated to give equal amounts of copper. Spraying was superior to dusting in checking late blight and returned the higher yields. The sprayed plots gave 255 bu. per acre with 3 per cent loss by tuber rot. Dusted plots yielded 226 bu. per acre, tuber rot being 5·4 per cent.

Sixteen fungicides were included in the spray trials for the control of late blight of potatoes at Fredericton. The products comprised seven fixed copper compounds, eight organics, and bordeaux mixture. With bordeaux and six of the fixed copper sprays, leaf infection dropped to below 5 per cent. Among the organic sprays, one formulation of zinc ethylene bis dithiocarbamate held leaf infection to one per cent while with another formulation a 30 per cent infection developed. In contrast with previous experience, Phygon XL proved unsatisfactory, the plot showing 30 per cent infection. Both Puratized and Spray 629 (zinc nitrodithioacetate) proved ineffective, the vines being completely destroyed as were the checks.

It is inferred that late blight infection was initiated at Ste. Anne de la Pocatiere in 1948 by air-borne spores as none of the potato sets affected with late blight rot and planted out developed into diseased plants. Sporangia were caught in spore traps on a few occasions and were easily identified; most of them did not shrivel even after four days at room temperature. Young plants were more resistant than older plants to late blight infection under field conditions. Potato plots planted at weekly intervals over a period of one month showed definite differences in disease infection. However, the degree of infection was not proportional to the age of the plant, as all the plots became more or less infected within ten days of the appearance of the first infection and, at the end of the season, there was very little difference in disease severity.

*Virus Diseases of Potato.*—Research conducted at the Fredericton laboratory in co-operation with the Physics Department, University of New Brunswick, has shown, in preliminary trials, that the radio-active isotope of phosphorus, $P^{32}$, tends to migrate faster in potatoes infected with leaf roll (Solanum virus 14) and slower in potatoes infected with rugose mosaic (Solanum virus 2) than it does in plants of the same variety (Green Mountain) free from these viruses. It was also found that, when peach aphids (*Myzus persicae*) were allowed to feed on the leaves of potato plants bearing $P^{32}$, they became radio-active and remained so for from 7 to 10 days following their removal from the plants. The radio-active aphids could be readily detected by means of a sensitive Geiger-Mueller counter. These findings indicate a difference in the rate at which phosphorus $P^{32}$ is taken up by healthy and virus-infected plants. They also suggest a practical means of marking aphids for greenhouse and field studies.

Proof has also been obtained that the disease designated as "haywire" is a secondary symptom of the bunch-top virus in such varieties of potatoes as Green Mountain and Canus and in certain seedlings. It was also shown that the bunch-top virus may produce symptoms in certain varieties resembling those characteristic of black-leg (*Erwinia phytophthora*). These symptoms included necrosis of the stem base, chlorosis and wilting of leaves and stem, and darkening of the tissues at the stem end of the tuber. These symptoms were produced by the bunch-top virus readily in Green Mountain and Sebago, which are quite susceptible to this disease. Bunch-top and black-leg have also been

found together in potatoes under field conditions. The similarity of certain symptoms of the two diseases indicates the possibility of confusing these important diseases in the field. An investigation of net necrosis in the Green Mountain variety has shown that this symptom is reproduced in the tubers of plants showing the secondary symptoms of leaf roll when such plants were infected with the bunch-top virus. This finding offers proof that one type of net necrosis is produced by a combination of the two viruses.

Further progress was made at Fredericton in testing potato seedlings for resistance to leaf roll, late blight, and common scab, as part of the potato breeding program conducted at Fredericton. During the year, 76 seedlings were retested for resistance to leaf roll. Five of these seedlings with good commercial qualities have also remained free from leaf roll under field conditions for four years. During the year, 6,102 new seedlings were tested for resistance to late blight. Of this group, 1,985 showed a high degree of resistance to the disease. Six hundred and thirty-five seedlings were tested for resistance to common scab; 47 showed marked resistance combined with good commercial qualities. Twenty seedlings with resistance to late blight were tested for resistance to bacterial ring rot; twelve of these seedlings failed to show ring rot during this test.

Additional evidence was obtained at the Ste. Anne de la Pocatiere laboratory, on the uneven distribution of mosaic virus in potato tubers. In a test in which tuber-indexing was compared with the tuber-unit method of planting, 0·8 per cent of the tubers that were indexed proved to be infected with mosaic in the field. In another experiment in which every 'eye' from a lot of tubers was planted separately, 23 per cent of the tubers affected with mosaic produced both healthy and mosaic-affected plants. The destruction, in 1947, of potato vines before August 18, nine weeks after planting, resulted in a crop free from leaf-roll in 1948. However, the early killing reduced the yield by two thirds. The percentage of mosaic plants rose in the plots in which the vines were killed after August 27. According to observations made during the last few years, the rate of spread of virus diseases is much higher in southwestern Quebec than in the northeastern parts of the province. In some localities along the lower St. Lawrence, virus diseases have made practically no progress during the last three years. This low rate of dissemination is correlated with the absence or scarcity of insect vectors.

In comparing the value of tuber-indexing with that of tuber-unit planting for the elimination of virus diseases in seed potatoes, 1,000 tubers from the progeny of stock indexed in the greenhouse 4 consecutive years, were indexed at Ottawa in 1948 and planted out of doors. Another 1,000 tubers from the progeny of plants produced by stock that had been planted by tuber-units during the previous 4 seasons, were planted by tuber-units in the field in 1948. The 1,000 indexed tubers produced 960 apparently healthy units (96%), whereas the 1,000 tubers planted by tuber-units without indexing produced 836 such units (83·6%). There was much current-season infection, particularly in the tuber-unit plot, which accounts for the great increase in the percentage of virus diseases. The average percentage of virus infection in the field during the 5 years of the experiment was 4·4 for the tuber-indexed stock, and 12·4 for the stock planted by tuber units.

Observations on bunch-top (purple-top) of potatoes showed that the virus, when transmitted to the tubers, is not always evenly distributed in them. Two of the tubers that were indexed in connection with the tuber-indexing and tuber-unit planting experiment, produced bunch-top plants in the greenhouse, but when they were planted out of doors one produced 4 bunch-top plants and the other, 2 bunch-top plants and 2 normal plants. Five tubers that had produced healthy plants in the greenhouse, produced from 1 to 4 bunch-top plants in the field. In the tuber-unit planted stock, 6 tubers produced from 1 to 4 bunch-top

plants. Although only a low percentage of the tubers are ever affected by purple-top, it will not be possible to eliminate all infected tubers by tuber indexing.

In the "Aster Yellows Virus Garden" planted at Ottawa to test the hypothesis that bunch-top (purple-top) of potatoes is caused by the aster yellows virus, Sebago potatoes were interplanted in randomized rows with the following plants known to be susceptible to aster yellows: China aster, carrot, celery, tartarian buckwheat, and zinnia. Although 19 per cent of the aster plants became infected with yellows, all other plants remained healthy. The failure of the potato to become infected leaves the identity of the bunch-top virus still in doubt.

Several aspects of the development of phloem necrosis in potato tubers are being studied at Edmonton. It has been shown that the feeding of a large population of the aphid *Myzus persicae* on potato vines at any stage of maturity will not cause phloem necrosis in the tubers.

In co-operation with the Division of Entomology, a search was begun for the vector of the potato witches' broom virus. Nineteen collections of insects from the Cariboo were shipped by air to the Vancouver laboratory, where the insects were caged first on diseased plants, and then on healthy. They were then killed and preserved. The tubers from the healthy plants on which they had fed were harvested and will be planted in 1949. Should transmission have occurred in any instance, the insects in the collection involved will be identified and further tests made with each species in the collection. In addition, vector trials with certain individual insect species were begun during the winter of 1947-48 and the tubers from the plants used are now sprouting. While it is still too soon to be certain, there are indications that successful transmission was obtained with some of the species under test.

To investigate the possibility of mechanical transmission of mild potato mosaic by planting machines of the type that impale the seed pieces on picks, seed pieces were stabbed with forceps dipped in a juice extract from mosaic leaves. Some transmission was obtained, the symptoms following the same pattern as do those of current season, aphid-transmitted infection.

*Potato Vine Killers.*—Potato vine destruction is practised widely in Prince Edward Island. This important supplementary measure in the control of late blight received further study in 1948. Sodium arsenite destroys the plants slowly, a disadvantage which was reduced appreciably by the addition of common salt. A new British product, Lotemcide, at a 10 per cent concentration, destroyed the vines rapidly. It has also been noted that the amount and intensity of discoloration in tubers from plants killed at different stages of development, using dinitro ortho secondary butyl phenol, increased uniformly with the age of the plants. The cause of the discoloration has not been satisfactorily revealed by these tests although it has been observed that the condition is correlated with the rapidity with which the plants are killed. It has been indicated that the amount of moisture available to the plants may affect the degree of vascular discoloration inasmuch as tubers from plants killed under drought conditions showed the most injury.

Further tests with herbicides were conducted at Ottawa in 1948 to determine their suitability for killing potato tops prematurely as a means of preventing late blight tuber-rot. Handy Killer (sodium arsenite), Sinox General (dinitro ortho secondary amyl phenol), and Dowspray 66 Improved (dinitro ortho secondary butyl phenol) were applied to individual plots on August 31, September 8, and September 16. Handy Killer required 10, 8, and 8 days; Sinox General 7, 6, and 4 days; and Dowspray 66 Improved 5, 4, and 4 days, respectively, to kill the plants after application on the above dates. The average ratings for internal discoloration in the tubers, determined by examining 200 tubers from each plot at harvest time and a similar number after 4 months' storage, were as follows: Check, 21 and 2; Handy Killer, 62 and 9; Sinox General, 71 and 11;

and Dowspray 66 Improved, 78 and 11. Most of the internal discoloration was slight and disappeared in storage. With all treatments, the rate of killing increased as the season advanced and the plants matured. In general, the incidence of internal discoloration varied directly with the rate of killing the plants.

As vine-killing herbicides, Cyanamid dust and Dow 66 and Cyanate sprays were tested at St. Catharines to determine the amount and severity of vascular discoloration that resulted from the treatments. Dow 66 produced slightly more than either of the other two but in no case was the injury severe. Soaking the ground with water immediately after the application of the herbicides did not affect the amount of discoloration produced.

*Progress Report on the Ontario Co-operative Scab Project.*—The units co-operating on the potato scab project in Ontario are the Departments of Chemistry, Soils, Field Husbandry, Bacteriology and Botany of the Ontario Agricultural College; Department of Botany, University of Western Ontario; and the St. Catharines Laboratory. Included in the general scab project is the testing of resistant varieties in Ontario under the supervision of the Department of Field Husbandry, Ontario Agricultural College, and the Division of Horticulture, Central Experimental Farm, Ottawa.

Several leads were obtained from work in 1948, the first year of the project. The more important of these are:

(1) Scab was reduced as much as 75 per cent following the use of soybeans as a cover crop. No reduction was observed following rye, clover, timothy, and certain other crops.

(2) Studies on the decomposition of soybeans have indicated the presence of an extract that inhibits the growth of the scab organism.

(3) Data collected by the survey on 44 farms in six counties indicated a correlation between humus content of soils and incidence of scab. Less scab was found in soils of higher organic content. The survey also indicated a possible correlation between pH of the soil and incidence of scab. The preceding crops appear to have a definite influence on scab. Less scab was present in soils previously cropped to legumes or in pasture than in soils preceded by hay or potatoes.

(4) Soil analyses generally bore out the field observations of correlations between scab and organic content and between percentage of scab and pH. In addition, it was found that various applications of sulphur to soils had no appreciable effect on incidence of scab.

(5) No correlation was evident between total numbers of actinomycetes in the soil and the percentage of scab on tubers.

(6) No correlation was observed between nitrate production and the percentage of scab on tubers.

(7) Fertility levels of phosphorus and potash in the soil appeared to have no relationship with incidence of scab.

(8) Twelve scab-resistant seedlings and three scab-resistant varieties were tested in six counties. Though no seedling or variety was immune to scab, one of the seedlings showed only a slight infection in all tests. For instance, this seedling showed only 0·6 per cent scab, whereas the Katahdin variety on the same soil had 26·7 per cent scab.

(9) A sum of $1,000 contributed by the growers was used for a survey of the literature. To date, 500 references with abstracts and 400 without abstracts have been listed on 5″ × 7″ filing cards in triplicate for use of the co-operating institutions.

*Soil Microbiological Studies in Relation to Potato Scab.*—Studies were continued at St. Catharines on the beneficial effect obtained by the incorporation of successive crops of soybeans with scab-infested soil. A stimulating effect

on bacteria requiring amino acids as well as a negative correlation between the "bacterial balance index" and scab incidence were observed. Marked quantitative changes in the predominating fungus flora were also observed in soil both on, and apart from, the potato tubers. These changes were not related to nutritional requirements of the fungi. Pathogenicity tests indicated a reduction in the number of parasitic types of actinomycetes in the soil and on the tubers of a subsequent crop of potatoes.

*Bacterial Ring Rot.*—Treating potato sets, cut with a contaminated knife, with Puratized and Isothan reduced bacterial ring rot infection at Ste. Anne de la Pocatiere to 6 per cent as compared with 80 per cent in plots planted with untreated contaminated sets. Solanin produced in tubers has no prophylactic properties against *Corynebacterium sepedonicum* when the pathogen is inoculated into green tubers. Other studies showed that there was some correlation between the rate of movement of the pathogen in the plant and the part of the plant inoculated as well as the position of the part on the plant. Over fifty soil organisms, isolated from potato tubers affected with ring rot, showed some antagonism to the pathogen and, of these, 23 are *Actinomyces* spp. Among the bacterial organisms only two were able to rot potato tubers at room temperature.

In 1948, tubers from 30 lines of the Commonwealth Potato Collection that had not in previous tests shown any bacterial ring rot infection, were inoculated with the causal organism (*Corynebacterium sepedonicum*) and planted in the greenhouse at Ottawa. At harvest time, infection was determined by a microscopical examination of smears from the tubers, and 13 lines were found infected. The remaining 17 lines which have shown no infection to date will be retested.

Further tests were made to determine the degree of resistance of the Teton potato variety to bacterial ring rot. Three lots of Teton tubers were planted in the field, one lot without treatment, one lot needle-inoculated with a suspension of *Corynebacterium sepedonicum* from cultures, and one lot inoculated by cutting into sets with a knife contaminated by cutting through a diseased Green Mountain tuber. For comparison, healthy Green Mountain tubers needle-inoculated with the same pure cultures were also planted. No symptom of ring rot was observed on the Teton plants. At harvest time, the tubers were examined by cutting them at the stem end. All tubers suspected of being infected were checked microscopically for the presence of the ring-rot organism. The percentage of plants with one or more infected tubers was as follows: needle-inoculated Teton, 6·3; knife-inoculated Teton, 4·3; needle-inoculated Green Mountain, 100. The Teton checks were free from ring rot. Most of the Green Mountain tubers were completely decayed, but in the infected Teton tubers the damage was slight and confined to the stem end. These experiments indicate that Teton possesses a high degree of resistance.

*Other Diseases.*—Magnesium deficiency continues to be an important disorder of potatoes in Prince Edward Island. Corrective measures are more effective when soil amendments containing magnesium are accompanied by better cultural practices ensuring adequate humus in the land. Solmago and dolomitic limestone decreased injury from magnesium deficiency, increased the magnesium in the plant tissues, and gave higher yields. Dolomite (20 per cent MgO) applied at the rate of 1,200 pounds per acre reduced foliage symptoms to a very low level. Tests over a 3-year period show that a magnesium content of one per cent MgO provided in standard fertilizer mixtures is inadequate for low-magnesium soils. Because such soils are almost invariably highly acid, they require dolomitic limestone applications, which correct the acidity as well as supplying sufficient magnesium.

Storage rot (*Fusarium sambucinum* f. 6) of potatoes continues to cause serious losses in Prince Edward Island. The disease developed rapidly in inoculated tubers at 50°F., but no rot was present in tubers held in storage at 35°

and 40°F. for two months. High temperatures during harvest were conducive to rapid decay in large storage bins where cooling-off was slow. Dusting the tubers with a fungicide as they are placed in storage has given disappointing results, the control of rot being insignificant.

Verticillium wilt of potatoes was reduced considerably by treating the tubers with Semesan Bel. In a replicated experiment with 1,000 each of treated and untreated diseased cut seed-pieces, treated lots developed 8·2 per cent wilt and untreated lots 49·0 per cent wilt. Healthy lots, treated and untreated, developed a mere trace of the disease. Isolations from tubers affected by dry rot revealed that *Fusarium caeruleum* is prevalent and more commonly associated with storage rot of potatoes in Alberta than are other *Fusarium* spp. Freshly cut potato sets treated with Spergon or Fermate at Edmonton were completely protected against attack by *F. caeruleum* in the soil and these chemicals did not retard the natural healing processes of the cut surfaces.

## Diseases of Vegetables and Field Crops

*Pea Diseases.*—To test further the varietal reaction of pea varieties that had previously been found to show resistance to *Ascochyta Pisi*, plants grown in the greenhouse at Ottawa were inoculated with a spore suspension of the fungus. All varieties tested still proved to be resistant with the exception of *Pisum Jamardii*, which became heavily infected. This is a co-operative project with the Division of Horticulture.

In testing the effectiveness of seed treatment for the control of the Ascochyta diseases of peas, Thomas Laxton peas naturally infected with *Ascochyta Pisi*, *A. pinodes*, and *A. pinodella* were treated with 22 different fungicidal materials and planted in the field. None of the treatments gave effective disease control, but some of the treatments gave significant increase in yield.

Treatment of pea seed with fungicides at Edmonton did not reduce appreciably infection with *Ascochyta* spp. in an infested soil. Field tests indicate the necessity of planting pea seed free from infection by Ascochyta in soil free of the pathogen. No appreciable differences in resistance to *Ascochyta* spp. were observed in 17 varieties. A survey showed that root rots caused by *Rhizoctonia* spp. and *Fusarium* spp. are prevalent and cause considerable damage.

After exposure to contamination by several species of mould fungi, pea seed was treated at Vancouver with various fungicides and planted. The percentage of stand in the uncontaminated lots ranged from 78 to 82; in those contaminated with *Penicillium*, it ranged from 62 to 65; in those with *Pythium*, from 42 to 45; and in those with *Botrytis*, from 34 to 40. Treatment with Arasan, Semesan, and Spergon increased the stands markedly. Ceresan M was slightly less effective and Ceresan caused significant injury.

*Bean Diseases.*—Co-operative tests at Ottawa with the Division of Animal Pathology to devise a serological method for determination of common and halo blights were continued. To corroborate the laboratory diagnosis obtained serologically by the complement-fixation method, seed of all samples was sown in the fields. Although the correlation between laboratory and field tests was not complete, there appears to be sufficient promise in the method to warrant further research with certain modification of procedure.

In testing 38 bean varieties for resistance to common and halo blight, caused by *Xanthomonas phaseoli* and *Pseudomonas phaseolicola* respectively, plants grown in the field were inoculated with water suspensions of the causal organisms. Inspection of the inoculated plants showed that all 38 varieties were susceptible, with 3 varieties displaying a slight degree of resistance. These tests were made in co-operation with the Horticultural and the Cereal Divisions.

In co-operation with the Cereal Division, varietal reaction of 72 varieties of bean to anthracnose, caused by *Colletotrichum Lindemuthianum*, was tested in the field by inoculating the seed at the time of sowing. It was found that 12 varieties were highly resistant and 13 varieties showed only very slight infection.

*Tomato Diseases.*—Quadruplicate plots of tomatoes at Kentville received six spray treatments for the control of late blight. Seven applications were made at 10-day intervals using bordeaux (at two strengths), Phygon, and Tribasic copper sulphate in straight schedules and two alternating schedules of Zerlate and bordeaux, and Zerlate and Tribasic copper sulphate. Late blight control was complete in all the treated plots. Checks were severely blighted.

In 1947, it was found at St. Catharines that certain fungicides caused no apparent injury when tomato plants, before being transplanted in the field, had their tops dipped in solutions of fungicides as an added precaution against late blight. In 1948, the effect of this treatment on yields was tested. It was found that the yields computed from the first five pickings were increased when the tops were dipped in Basicop, Karbam W, and Phygon, but not when the whole plant was immersed in the fungicide. The solutions that either reduced or showed little effect on yield when the tops were dipped in them caused no further reduction when the whole plant was treated. One material, HL331, caused the death of all plants when the roots as well as the tops were immersed in the solution.

Three years after its introduction into a plot of Fox sandy loam soil at the Harrow laboratory, *Fusarium Lycopersici* was still capable of causing considerable wilt of tomatoes in 1948. Moreover, the fungus had spread some distance beyond the original confines of the plot, where tomatoes had not been grown previously.

*Fusarium Wilt of Muskmelons.*—This disease caused serious losses in many fields in the southern part of Essex county, Ont. Disease incidence varied from a trace to 85 per cent. Periodic surveys, made during the summers of 1946-48, have revealed that, in this area, only a small acreage suitable for muskmelon growing is free of the wilt fungus. Furthermore, the acreage on which it is possible to grow a profitable crop is rapidly diminishing.

Under the co-operative project with the Harrow Experimental Station, several $F_2$ and $F_3$ hybrid populations were planted in the field in wilt-infested soil. Among the $F_2$ populations resistance was found to be dominant, with susceptibility ranging from 5 to 36 per cent.

Fusarium wilt of watermelons was discovered in 1948 for the first time and was found to be causing serious losses in three fields in the Harrow district. The isolate obtained from wilted watermelons, although morphologically similar to the muskmelon strain, was proved to be different pathogenically.

*Onion Diseases.*—A serious disease known locally in southwestern Ontario as "Yellow Patch" has been found in Spanish onion seedlings growing in greenhouses. While occasionally all seedlings in some flats were attacked, usually only sections in the flats were affected. Briefly, the symptoms consisted of a yellowing and dying of leaves, accompanied by a necrosis of the seminal and primary roots of the seedlings. *Pythium irregulare*, which was isolated consistently from necrotic roots, was demonstrated to be highly pathogenic to onion seedlings and capable of causing extensive pre-emergence and post-emergence damping-off. Moreover, this fungus was observed to attack the roots of older seedlings and appeared to be responsible for some of the root necrosis reported in them.

Preliminary experiments with onions at Harrow indicated that when Arasan was thoroughly mixed in the top two inches of smut-infested soil, the fungicide was capable of reducing incidence of smut to a very low level. Further experiments

showed that the disease could be adequately controlled by treating narrow bands ($1\frac{3}{4}''$ wide and $1\frac{1}{4}''$ deep) in which the seeds were planted, using the chemical at the rate of 6·28 gm. per cu. ft. of soil. On a field basis, if applied to onion seed rows spaced 16 inches apart, eight pounds of Arasan would treat one acre.

Experiments for the control of downy mildew at Summerland were conducted on both the seed and the bulb crop of onions. On the seed crop, the percentage of healthy stalks after treatment was: with iron carbamate spray (2-100), 74·6 (three weeks after treatment); with copper oxychloride (3-100), 70·3; with zinc carbamate (2-100), 40·7; with 10 per cent iron carbamate dry dust, 21·4; and check, 13·5 per cent. In a three-spray schedule on the bulb crop, nine fungicides were used in liquid sprays and one as a 10 per cent dust applied with a liqui-dust machine. As mildew seriously interferes with bulb development, the value of the individual treatments was estimated from the respective weights of 1000 bulbs from each plot. The iron-carbamate liqui-dust treatment increased the yield 70 per cent. The spray treatments were less effective; Fermate and Phygon were among the more promising.

*Soybean Diseases.*—Results of six years' experiments on soybean diseases were compiled. During the period from 1942 to 1948, in which the area planted to soybeans in Canada increased from 10,000 to 94,000 acres, 14 parasitic diseases have been reported by the Harrow laboratory as occurring on soybeans in the high-production area of southwestern Ontario. Included among these diseases are several that have constituted a definite and serious menace to soybeans in Illinois, Indiana, Iowa, and other areas where the crop is grown intensively. In order to keep abreast of the disease situation as it might develop in Ontario, a carefully-planned seed-treatment project, inaugurated in 1943, has been carried out continuously during the last six years.

In only one of the six years of the tests has treatment of seed resulted in a significant increase in yield over non-treated seed. In that particular case, the seed was of exceptionally poor quality. In the tests of the other five years, it was found that although seed treatment might give increased stands over non-treated checks, nevertheless, in general, yields remained unaffected. At the moment there would seem to be no reason for modifying the view that where high-germination, good quality soybean seed is planted, seed treatment is of doubtful value.

*Blackroot of Sugar Beets.*—With the harvesting of the mature crop in the autumn of 1948, results of field treatment of infested soil with Arasan for the control of blackroot of sugar beets in Ontario became available. In the three completed field trials in which all operations were carried out in accordance with accepted cultural practice for the crop, not only were stands of seedlings increased, but, in two of them, yields also proved to be significantly greater in the Arasan-treated than in the untreated soil. The actual increases in yield amounted to 1·2 tons per acre in one of the two tests and 1·5 tons per acre in the other. The results of the field trials as indicated above confirm those of many exploratory and more precise greenhouse experiments mentioned in previous reports. Reports were also obtained from sugar companies in Michigan, where commercial trials of the use of Arasan were conducted on a large scale, and in all cases both increased stand of seedlings and yields were obtained.

*Control of Damping-off in Vegetables.*—The use of Arasan (tetramethyl thiuramdisulphide) to control damping-off of vegetables was intensively investigated. Greenhouse experiments with this chemical in seed, soil, and combination seed and soil treatments were continued and extended. In peppers, the combined seed and soil treatment proved to be the most effective in controlling both the pre- and post-emergence phase of the disease. The most effective rate of application of the protectant to the soil was determined to be 3·1 gm. per cu. ft.

Although soil treatment alone did not control pre-emergence damping-off as effectively as seed treatment alone, the former proved effective in protecting the pepper seedlings against attack after emergence.

In several commercial greenhouses, where the Arasan treatment was used in the spring of 1948, highly satisfactory control of the disease in peppers and eggplants was obtained. In one greenhouse where the Arasan treatment was employed, losses from damping-off in eggplant seedlings were 45 per cent lower than in the untreated controls.

Similar treatments with several other vegetables highly susceptible to damping-off have been investigated. The combined seed and soil treatment with Arasan was highly effective in controlling the disease in Spanish onions and spinach and was more effective than either seed or soil treatment alone. However, seed treatment alone was found adequate to control damping-off in tomatoes, cucumbers, and muskmelons. Both seed and soil treatment with Arasan proved toxic to lettuce seedlings.

*Turnip Club-Root.*—In studies on club-root of turnip at Charlottetown, very little, if any, correlation has been observed between the resistance of the seedling root hairs and the resistance of the mature plant. In hybrids exhibiting wide variation in susceptibility to club-root in the field, infection of the seedling root hairs was heavy and approximately the same as under controlled laboratory tests. From these experiments, it is concluded that the root hairs of swede turnips in the seedlings stage possess no resistance to club-root.

*Downy Mildew of Hops.*—In the fifth and last year of the spray test for the control of downy mildew of hops in eastern Ontario, bordeaux mixture 10-10-100 and C.O.C.S. were equally effective. The addition of the spreader-adhesive "Orthex" increased the efficiency of both fungicides. The plots sprayed with C.O.C.S. gave a slightly higher average yield than those sprayed with bordeaux.

*Celery Blights.*—In testing fungicides for the control of blights at St. Catharines in 1948, four materials were used for the first time and two received their second test. The following disease ratings were recorded for each of the materials used: bordeaux mixture 3·0, Bordow 3·0, Phygon 2·0, Karbam W 3·0, Parzate 1·0, Gooderite ZAC 2·5, 340C 6·0, and control 8·0.

A 10 per cent iron carbamate dust applied with a liqui-dust machine in a seven-spray schedule at Summerland gave 97·9 per cent of healthy plants at harvest, and a dry fixed copper dust in a similar schedule gave 64·0 per cent.

*Black Root-Rot of Tobacco.*—Investigations of black root-rot of tobacco at Harrow were centred largely on a study of the causal organism (*Thielaviopsis basicola*). Isolations from widely separated tobacco-growing areas in Ontario and Quebec indicated the existence of both dark-coloured and light-coloured race groups within the named species. Furthermore, on the basis of colour distinction and other morphological and physiological characteristics, at least 3 races were recognized within each of the dark and light groups. The dark race group proved to be more pathogenic than the light race group except in the Quebec isolates. The Delhi isolates and race groups were the least pathogenic of all cultures studied. The Harrow and the Quebec isolates appeared to be identical morphologically and physiologically.

## Crop Inspection and Seed Examination for the Control of Seed-Borne Diseases

*Seed Examination.*—Laboratory examination of 418 samples of vegetable and field crop seeds to determine their health condition were completed at Ottawa and individual health reports were issued. Of the samples examined, 248 were submitted with applications for Foundation, 53 for Registered, 97 for

Certified status, one was an imported sample, and 19 were commercial samples. The samples comprised seed of the following crops: beans 46 samples, cereals 5, clovers 10, corn 46, flax 31, grasses 19, peas 88, other vegetables 144, other crops 29. Over half the samples were judged suitable for seed purposes; quite a large percentage of the bean, pea, and vegetable samples were suitable if treated; and a considerable percentage of the corn and pea samples were found unsuitable.

Of the 191 samples of Foundation and Elite cereal seed that were examined at Winnipeg during the winter season of 1948-49, only 16·2 per cent were found to be free from injury or disease, as compared with 24·8 per cent the preceding year. Smut was the most common defect, being present in 55·3 per cent of the wheat samples, 84·3 per cent of the oat samples, and 91·8 per cent of the barley samples. These percentages represent marked increases in smuttiness over those found in the 1947 crop. An increase in smut was evident in all parts of Canada from which samples originated.

A survey to determine the comparative health condition of domestic and allegedly disease-free imported seed of peas and beans was conducted at Ottawa in co-operation with the Plant Products Division. Samples of 151 pea and 135 bean seed stocks of both domestic and foreign origin were tested for disease in the laboratory and in the field. Laboratory examination of the pea seed samples showed that 85·4 per cent of the domestic samples and 92·7 per cent of the foreign samples were suitable for seed purposes. For beans, 71·4 per cent of the domestic samples and 96·2 per cent of the foreign samples were considered suitable. In the field inspections of plants grown from the same seed stock, it was found that, for peas, 93·7 per cent of the domestic and 92·8 per cent of the imported seed samples were suitable, whereas, for beans, 46·4 per cent domestic and 55·7 per cent imported samples were considered suitable.

Field inspections for disease in 104 crops in the Horticulture, Cereal, and Forage Divisions of the Central Experimental Farm were made and reports on each of the crops inspected were issued in accordance with the regulations of the Canadian Seed Growers' Association for Foundation and Elite seed crops.

Over 225 species of seed-borne fungi have now been identified and are now maintained in culture at Ottawa. In addition, numerous unidentified fungi and isolates of all species from various hosts are kept in culture for identification and pathogenicity studies.

*Suggested Improvement in Technique.*—Improvement in the method of examination of seeds for seed-borne pathogens has been suggested by preliminary studies made at Ottawa. By the present method, all seeds are surface disinfected before plating on agar media. This step is essential in order to eliminate surface-borne saprophytic moulds, etc., which would obscure by their rapid growth important internal pathogens, and thus no evidence of externally-borne fungi can be obtained. By soaking a sample of 100 seeds in sufficient water to cover the seed, shaking, and allowing to stand for 18 hours, surface-borne spores are released into the water. When the water is centrifuged for 10 minutes and the precipitate is examined microscopically, it is possible to establish the presence of surface-borne spores and in a general way to obtain some idea of the spore load carried by the seed. It is suggested that tests be conducted for all important pathogens to determine whether or not spores are present and remain viable on the surface of the seeds for any length of time, and whether or not these spores are capable of initiating infection. Spores of *Ascochyta Pisi* were found on the surface of pea seed and found capable of infecting young seedlings. It has also been found that the following pathogens may be surface-borne as well as internally-borne: *Polyspora Lini* on flax, *Fusarium moniliforme* on corn, *Alternaria brassicicola* on cabbage, and *Colletotrichum Lindemuthianum* on beans. By combining the plating test with the centrifuge test, the entire fungus population of a seed sample can be determined, and thus it is possible to ascertain whether a given sample of seed is suitable with or without seed treatment.

*Seed Health Approval Plan.*—To determine the practicability of a Seed Health Approval Plan in Canada, laboratory tests of selected seed stock of peas and beans and field inspections of the parental crops were made at Ottawa in co-operation with the Plant Products Division. The purpose of the preliminary examinations is to ascertain if suitable disease-free seed is available for the initiation of the plan and if there are certain areas environmentally favourable for the production of seed under the plan. Laboratory examinations, involving the testing of 80 samples of peas and 28 samples of beans, were made and the results, correlated with field inspection reports, formed the basis for the selection of the most promising seed lots for further propagation.

In co-operation with the Horticulture Division, periodic inspections for freedom from disease of greenhouse-grown bean plants have been made. These plants are grown as a source of seed for future multiplication of Foundation stock.

## Diseases of Ornamental Plants

*Bulb Diseases.*—Greenhouse and field tests at Saanichton indicate that, under conditions in Vancouver Island, the planting of gladiolus corms infected with scab (*Pseudomonas marginata*) usually gives rise to healthy plants. The disease develops appreciably in such plants only under conditions favourable to the bacterium. A number of corm treatments had no effect upon the incidence of scab. However, a 15-minute corm dip in Ceresan (1-400) exerted the most favourable effect upon growth. A 15-minute lime-sulphur (1-10) dip adversely affected the growth of the corms.

Primary infection in tulip plantings was decreased to a greater degree by a 2-minute bulb dip in Semesan Bel (1-60) than by a 20-minute dip in Wettable Spergon (1-100). Dusting tulip bulbs with 2 per cent Ceresan seriously affected subsequent growth.

The chrysanthemum leaf nematode (*Aphelenchoides ritzema-bosi*) developed large populations from larvae to adults upon the foliage of Croft lily.

The lily leaf nematode (*Aphelenchoides olesistus*) occurred in the stock of two out of fourteen local growers.

The fumigation of narcissus bulbs with methyl bromide (4 lb. to 1,000 cu. ft.) at approximately 60°F., for the control of bulb fly, slightly delayed the appearance of bloom, but otherwise did not appear to affect growth adversely.

Dithane has been found to be less stable than Parzate, its corresponding zinc salt, and certain other organic fungicides. The instability of Dithane appears to account for its high initial fungistatic effect and short fungicidal life when applied as a spray, in comparison with Parzate, which is merely a protectant but remains effective much longer.

A study of Dithane, Parzate, Fermate, and Zerlate against *Botrytis* spp. showed that Dithane exerted by far the strongest fungistatic effect. Fermate exerted an intermediate, and Parzate and Zerlate a low effect. The results suggest that Parzate or Zerlate alone are not sufficiently fungistatic to be used as a spray material in the control of *Botrytis Tulipae*. The inclusion of Dithane as a spray material for tulip fire control is suggested as a means of preventing spread at the critical period early in the season.

*Intercepted Shipments of Imported Nursery Stock.*—Samples were examined for disease from 250 variety lots out of 169 shipments. Shipments examined were almost exclusively from Holland and the United States. Gladioli, tulips, irises, hyacinths, crocuses, tomatoes, and narcissi, in descending order, comprised the bulk of the material. Penicillium rot of iris; scab, penicillium rot, core rot, dry rot, hard rot, and mechanical injury of gladiolus; and mechanical injury and fire of tulip were the defects seen most frequently. Late blight was detected

twice in two shipments of young tomato plants from the southern United States, indicating one way in which this disease may become established each year in the canning crop districts of Ontario.

*Bulb Inspection.*—During 1948, officers of Saanichton laboratory served as advisors to the new Bulb Certification Service, and will continue to do so in future as required. Applications for certification in 1948 included 424 fields totalling 13,150,000 bulbs on Vancouver Island, and 164 fields totalling 3,289,000 bulbs in the Fraser Valley.

The inspections revealed that 12½ per cent of a total of 153 narcissus fields inspected carried an excess of 2 per cent eelworm infection. Nearly all narcissus fields carry virus to some extent. Selected large bulbs carried far less virus than field run and small size planting stock. Basal-rot in narcissus was variable from a trace to 16 per cent. Bulbs in low wet areas were more seriously infected than in well drained fields.

Although only 17½ per cent of 304 tulip fields carried an excess of 1 per cent "fire heads" or primary tulip fire infection, the cool wet weather in May promoted the spread of conidial infection and caused some loss in bloom and bulb yield.

About 5 per cent of 7½ million iris Wedgewood inspected carried an excess of 2 per cent virus, hence about 95 per cent of the iris entered for certification passed field inspection.

Bulb eelworm was found in the main iris stock. The amount of infection varied with the size of the bulbs, being much greater in large bulbs. Infection was not serious.

*Treatment of Cuttings.*—The practice of immersing cut holly in a naphthalene acetic acid solution, 100 ppm., has been found by the Saanichton laboratory to be undesirable. A spray treatment with the same solution is recommended to avoid foliage discoloration and leaf drop.

The rooting and survival of four classes of cuttings, Green Column Cypress, Allumi Cypress, Tamarix, and Sequoia, were favourably influenced by dusting the bases with Arasan. Dusting with Fermate exerted a particularly favourable effect upon Tamarix, Sequoia, and Allumi Cypress, but had no significant effect upon Green Column Cypress. Spergon exerted a favourable effect upon both species of Cypress, but not upon Tamarix. The inclusion of a trace of naphthalene acetic acid with the fungicidal dusts had little or no effect.

## DIVISION OF CHEMISTRY

### Animal Nutrition

*Factors Affecting the Nutritive Value of Livestock Rations.*—The nutritive value of livestock rations may be affected by (1) the combination of feeds, (2) the quantities of the different feeds in the ration, (3) the total quantity fed, (4) the percentage of protein in the ration and (5) the method of feeding. These factors are being investigated with cattle, sheep and swine. The criteria used for estimating the nutritive value are the content of digestible nutrients in the rations and palatability.

During the year, a number of digestion trials were carried out with beef cattle and swine. Those with cattle dealt with two factors: the effect of increasing the amount of carbohydrate or protein supplements in rations, and the effect of various combinations of feeds. The swine experiments dealt with various combinations of feeds used in swine rations.

*Evaluation of Canadian Feeding Stuffs.*—A study is being made of the total digestible nutrients and digestible protein in Canadian grains, concentrates and roughages. Particular consideration is currently being given to some of the newer oilseed meals,—rape, sunflower and mustard.

*Nutritive Value of Feed Proteins.*—The comparative values of feed proteins for cattle, sheep and swine are being studied from the standpoint of meat production and wool growth. During the year, interest with beef cattle centred on the place of urea in commercial feeds for ruminants. A number of animals were fed rations containing this compound, slaughtered and analysed. With swine, metabolism trials were carried out during the growing period on a number of vegetable and animal protein concentrates.

*Pasture Evaluation.*—A co-operative investigation has been carried out for the purpose of establishing a technique of estimating seasonal yields of digestible nutrients from pasture herbage. During the 1948 season, digestion trials with sheep were carried out in conjunction with grazing trials. The digestion trials gave the actual yield in total digestible nutrients of the pasture. These results were compared with live weight increases of the sheep on pasture.

*Conservation of Herbage.*—The conservation of herbage for winter feeding is an important problem. A co-operative project has been carried out on the nutritive value of herbage conserved by different methods. This involved a series of digestion trials with cattle on clover which had been artificially dried, field cured under different conditions, barn cured and made into silage.

*The Use of Isotopes in Metabolism Studies with Large Animals.*—Further work has been carried out on the use of the nitrogen isotope $N^{15}$ to study nitrogen metabolism in ruminants. Urea containing this isotope was fed to sheep. The distribution of its nitrogen in some of the body proteins and the elimination of its nitrogen from the body was determined.

*The Stability of Iodine in Iodized Salt Blocks.*—Since potassium iodide in block salt has been shown unstable under pasture conditions, two other iodine compounds have been suggested. These are thymol iodide and potassium iodate. Blocks of salt containing these were prepared. The effect of various weathering conditions on the iodine content was determined.

*Toxicity of Mineral Salts to Livestock.*—Sodium chlorate is used to kill herbage on roadsides. Its persistency on sprayed herbage and its toxicity to cattle were investigated. Studies were also carried out on the toxicity of solutions of different concentrations of sodium chloride.

## Vitamin and Physiological Research

The work of this unit covers fundamental research on biochemical and physiological aspects of vitamins and hormones, together with standard assays of commercial preparations submitted by inspectors. The work is carried on as a co-operative project of the Experimental Farms, Production and Science Services. The more fundamental aspects are reported here, and the standard assays under Plant Products Division of the Production Service.

*Vitamin D.*—Studies on the fundamental action of vitamin D in chicks have been continued. Radioactive $Ca^{45}$ and $P^{32}$ have been employed to trace the movement of calcium and phosphorus administered at certain times under known conditions of vitamin D adequacy. The progress of rickets can be gauged easily from X-ray photographs of the tibia-tarso-metatarsal joint.

The administration of additional amounts of vitamin D appears to have no influence on the net excretion of calcium or phosphorus by the non-rachitic

chick. Calcium administration, however, reduces the excretion of phosphorus. When vitamin D is administered to rachitic chicks, the net excretion of phosphorus is unaffected, but that of calcium is significantly reduced. By labelling calcium deposits with the radioactive isotope, it was possible to demonstrate that the change in the net retention of calcium as a result of vitamin D administration was due not to increased absorption from the gut, but rather to a retention of calcium in the bones and hence a decrease in the amount excreted into the intestines.

It would appear that vitamin D prevents the solution of calcium from the bone. This in turn improves the absorption of calcium from the intestines, and causes the increased net retention commonly observed. Further experiments are in progress to determine more accurately the site of vitamin D action.

It has been shown previously that the calcium and phosphorus of the diet affects only the length of the latent period of the vitamin D log.dose-response curve. The slope of the log.dose-response curve is unchanged. Experiments are in progress to determine whether a similar situation exists in regard to various forms of vitamin D having widely different degrees of effectiveness with mammals and birds. Preliminary results indicate that apparent differences which have been thought factual, have been due to variability in response inherent in the assay method.

*Vitamin A.*—Studies have been made of the site of conversion of carotene into vitamin A. Evidence pointing to the intestinal wall is impressive, but an enzyme has been found in the liver which will attack carotene. The kinetics of this enzyme have been investigated.

*Hormones.*—In the Report of the Minister, 1947-48, reference was made to experiments with dairy cattle in which administration of iodinated protein was found to stimulate milk and butterfat production at the expense of much of the body tissue. Adequate analytical methods, either chemical or biological, are required for assessing the activity of the iodinated protein. The determination of thyroxine iodine by analytical methods fails to provide values which can be used as an accurate index of physiological activity. Efforts have been directed toward the development of a bio-assay procedure. Several criteria for measuring the metabolic effect of thyroxine and iodinated casein have been investigated employing chicks and rats as test animals. The ratio of thyroid gland weight to body weight has been determined for large numbers of chicks after treatment with a goitrogen alone or together with concurrent injections of thyroxine. Differences in gland: weight ratios between treated and control birds are easily demonstrated, but successive hatches of chicks give different ratios. This, together with the variability within hatches, has made the method difficult to apply.

Thyroxine is said to increase the sensitivity of white mice to anoxia in closed vessels. This could not be applied satisfactorily to chicks over a wide dosage range and with varying time intervals between administration of test dose and measurement of anoxia time. Preliminary tests with white rats suggest that they may respond to lower dosage levels than those found necessary for chicks.

Hypertrophy of chick thyroids has been gauged by measuring epithelial cell heights and follicle diameters. The hypertrophy is correlated reasonably well with dosage levels of thyroxine and is less subject than thyroid weights to individual variations.

Other studies have included determinations of endogenous calcium, phosphorus and nitrogen, and of blood cholesterol as indices of metabolic activity in thyroxine-treated chicks.

## Food Investigations

The main work of the Food Investigation Unit has continued to be chemical control and investigation of processed foods, manufactured in establishments

licensed by various services of the Department of Agriculture, to maintain standards of grade and quality. Over 15,000 samples were examined during the past year. Service for the Health of Animals Division of Production Service included the analysis of 1,380 samples of packing-house products and materials used in their production and of imported edible gelatines for purity and conformity to standards. Service for the Fruit and Vegetable Division, Marketing Service, included the examination of 870 samples of processed fruit and vegetable and maple products for grade and quality under the Meat and Canned Foods and the Maple Industry Acts. A survey of over 300 samples of maple sugar and syrup gave evidence of a considerable amount of adulteration and demonstrated the value of this service in protecting the producer and consumer. Service for the Dairy Products Division, Marketing Service, showed another large increase in samples of milk powders analysed in connection with new grading and marketing regulations for export and interprovincial trade. Nearly 12,000 samples of milk powders were received for analysis as well as 350 samples of processed cheese and over 100 miscellaneous milk products. Three testing machines are now in operation to handle the large number of samples. In the three years since the grading of milk powders started, there has been a marked improvement in the quality of these products.

The laboratory has continued to co-operate with the Special Products Board in the examination for conformity to specifications of all export shipments of dried egg powder to the United Kingdom under agreement with the British Ministry of Food. Eight plants were in operation throughout Canada with an output of 203 carlots of sugared dried egg powder and 82 carlots of "straight" dried egg powder. This service has helped to maintain the good reputation which Canadian dried egg powder has achieved in the British market.

## Plant Chemistry

*Mineral Nutrition.*—Tissue analysis has been used as a tool in establishing the minimum requirements of the plant for such nutrients as potassium, phosphorus, calcium, magnesium, and nitrogen. Data from a survey of Ontario orchards, when compared with established values, showed satisfactory nutritional levels in almost all cases. In fertilizer trials with potatoes and carrots, at St. Clothilde, Quebec, there was a positive correlation between yield and/or the potassium content of petioles and leaves. The yields of onions were not correlated with the levels of potassium, phosphorus or nitrogen in the leaves.

*Polarographic Determination of Zinc.*—The recognition of the importance of zinc as a plant nutrient made it imperative to develop a rapid and accurate method for the quantitative estimation of that element in soils and plants. Existing colorimetric and polarographic methods were tedious and time consuming. A polarophragic method has been evolved which reduces both the number of reagents and the time required for a determination. The Division is now in a position to study the relation of zinc to deficiency diseases and to crop yields.

*Insecticides.*—The outer stalks of celery plants dusted 4 times with 3 per cent DDT powder at weekly intervals showed 5 p.p.m. DDT two weeks after the last dusting while the hearts showed less than 1 p.p.m. Cauliflower treated with DDT for cabbage worm control had less than 0·5 p.p.m. residue at harvest. Peaches and pears from the Vineland district were also examined for DDT residues. Two samples of peaches and two samples of pears were below the 7 p.p.m. tolerance while six samples of peaches were above the tolerance.

Parathion, a new and very effective insecticide, is extremely toxic to warm blooded animals. Studies have been initiated to measure its persistence in the soil and as a surface residue on plants and to establish whether or not it can be

taken into the plant system. Preliminary work indicated that parathion, as determined chemically, disappeared very rapidly, leaving surface residues which were of doubtful significance.

*Oil Seeds.*—The regular co-operative soybean and flax variety and environmental tests have been expanded to include a study of the effect of field applications of 2,4-D upon the quality of flaxseed. Studies of samples submitted by the Lethbridge Experimental Station showed that the sodium salt of 2,4-D when applied at from 2 to 8 ounces per acre had no effect on the oil or protein content of the seeds. The amine and ester, at the same rates of application reduced the oil content and increased the protein. There was no observed effect of any formulation upon the iodine number of the oil.

*The Ascorbic Acid Content of Commercially Canned Tomato Juice.*—At the request of Marketing Service, the Fruit and Vegetable Products Research Committee in 1947 undertook a survey of the ascorbic acid levels in commercial tomato juice. The objective was the possible grading of tomato juice on a basis of ascorbic acid content. Samples representative of the Ontario, Quebec, and British Columbia products have been analysed in 1947 and in 1948. The samples were selected to permit a study of the effect of manufacturer and/or locality, and the date of pack. The average ascorbic acid content increased progressively from East to West ranging from 14 mg./100 ml. in Quebec to 18 in British Columbia. Packs made later in the season contained slightly greater amounts of ascorbic acid than did early packs. The data indicate that a standard for Choice Quality of not less than 12 mg./100 ml. could be maintained.

*Plant Breeding.*—The unit has continued to co-operate with the Experimental Farms Service in cereal and forage breeding programs in order to permit selection on the basis of quality as well as on that of other characteristics. For example, sixty varieties of oats, chosen to represent a wide diversity of types, were grown at Ottawa, Winnipeg, Scott, and Agassiz. There was a wide range in chemical composition between varieties. One hundred pounds of the variety Erban contained as much protein as 130 lb. of Exeter, and 100 lb. of Joanette contained as much fat as 222 lb. of Exeter. The variations between stations were of a magnitude comparable with that between varieties and appeared to be related to both climatic and soil conditions.

*Freezing Preservation.*—The fruit and vegetable products laboratory continued to co-operate with the Division of Horticulture in its studies of methods of processing and storage. The work was expanded to include a study of the optimum stage of harvesting peas and corn.

## Soils and Fertilizers

*Soil Colloids.*—Field applications of limestone and manure, either alone or in combination, at Ste. Anne de la Pocatiere, Que., and Nappan, N.S., caused no appreciable changes in the amounts of colloidal material. The colloidal fractions represented from 10 to 27 per cent of the soil, yet contained from 60 to 75 per cent of the total soil phosphorus. There was an apparent relationship between the amount of Group I colloids, the percentage of the total soil phosphorus in that group, and crop yields.

Periodic laboratory treatment of a brown soil from Saskatchewan and an upland podzol soil from Quebec with lime, manure and superphosphate has been completed. These treated soils have been potted and are under comparison in the greenhouse. Striking differences in the growth of oats and alfalfa due to the treatments have been observed particularly in the case of the Quebec soil.

*Soil Organic Matter.*—Two humate (organic matter) fractions, separated from a sample representing the black soil zone of Alberta, by different procedures, were examined (1) to see if they were ligno-protein in nature and (2) to determine if they differed in chemical composition or merely in their mode of adsorption on the soil. A lignin-like material obtained from these fractions differed in many respects from wood lignin, being very low in methoxyl content, high in nitrogen, soluble in water but insoluble in even weak acid. However, the ultraviolet light absorption curve of a solution of this material was similar in many respects to that of lignin and related compounds.

Hydrolysis of the humate fractions gave solutions in which the proportion of amino-nitrogen to total nitrogen was lower than might have been expected if the soil nitrogen were combined largely as protein. Approximately half the nitrogen was not released on hydrolysis. The nitrogen content of the isolated lignin was little lower than that of the humate from which it was obtained, indicating that the union between the lignin-derived material and the nitrogenous compounds must have been very strong.

It was concluded that the similarities between the two humate fractions were more striking than their differences and it therefore appeared that the difference in method required for their separation from the soil was due to the way they were combined in the soil rather than to any fundamental chemical difference in the materials themselves.

*Fertilizer Studies on Soil Types.*—The effect of applications of 4-0-10 and 4-10-10 fertilizers on the phosphorus content of oats and alfalfa has been determined for one year of a proposed three-year experiment, using soils representing ten soil types. An important relationship has been observed between the phosphorus content of the crop grown on the 4-0-10 treatment and the response to phosphorus applied in the 4-10-10 treatment.

The effect of applications of 4-10-0 and 4-10-10 fertilizers on the potassium content of these crops has also been determined. Applied potassium resulted in the uptake of a large amount of soil potassium which apparently was utilized to a great extent by the straw despite little or no response in yield of straw.

The determination of readily-soluble soil phosphorus by a number of methods showed that several of these gave the same picture of availability. For instance, extractions with solutions of ammonium bisulphate (pH 3·0), potassium bisulphate (pH 2·0) and acetic acid (pH 2·6) gave similar results. Similarly, extraction with solutions of calcium sulphate (pH 3·0), calcium lactate (pH 3·7) and sodium acetate (pH 4·85) gave the same picture.

Correlation coefficients between amounts of "available" phosphorus as measured by laboratory methods and the uptake of phosphorus by the plants were determined. Results indicated that extraction of alkaline samples with potassium carbonate solution (1 per cent) and of acid to neutral samples with sodium acetate solution (pH 4·85) might be very useful in estimating the availability of soil phosphorus. Results of extraction of all samples with ammonium fluoride solution to measure what is termed "adsorbed" phosphorus were significantly correlated with phosphorus uptake by plants in the greenhouse.

The determination of readily-soluble soil potassium by three different methods gave results which showed good correlation, indicating that it would not greatly matter which method was employed. A close relationship was found between exchangeable soil potassium and the potassium taken up by the crop.

*Minor Elements.*—A study of the minor element content of a second group of thirty soils from Carleton county, Ont., was carried out. The ranges found for water-soluble boron, total cobalt, total copper, and total, exchangeable and easily reducible manganese were very similar to those found with the first group of thirty soils from the same soil types. Some information has been obtained

on the manganese content of the oats and alfalfa grown on these soils but no attempt will be made at this time to draw any conclusions. The investigation as now planned calls for the examination of a third group of thirty soils. When work on the group is completed, information will be available from nine soil samples from each of ten soil types in Carleton county and this can then be studied with a view to determining conditions in this area. However, a few cases of manganese deficiency observed in the oats grown on these soils in the greenhouse will probably require further investigation.

The seventh and last sampling of soil from a previously reported greenhouse experiment on manganese deficiency conducted by the Division of Bacteriology was completed. The soil from the cyanogas-treated pots was still considerably higher in available manganese than that from the manganese-treated, mulch-treated and control pots. An interesting observation was that the soils from the Mn-treated, mulch and control pots on being air-dried, contained approximately four times the amount of available manganese found in the moist soil. Air-drying of the cyanogas-treated soil increased the available manganese by only 10 to 20 per cent.

Five samples of peas were received from the Seed Testing Laboratory and examined for their boron content. These samples were taken in connection with a study of boron deficiency in peas where abnormal sprouts were produced in germination tests due to the lack of boron. Normal sprouts had a boron content of 9·0 p.p.m.; an intermediate type, not fully normal, contained 6·4 p.p.m. B; and the abnormal or typically boron-deficient peas had a boron content of 3·8 p.p.m. Where the sand in which germination took place was moistened with a 0·01 per cent solution of borax, the boron content of the peas was increased to 74·0 p.p.m.

A series of eight soils was received from the Dominion Experimental Station at Fredericton, N.B., for the purpose of determining their content of boron, cobalt, copper and manganese. Results indicated that these samples were well supplied with cobalt and copper but their content of water-soluble boron was somewhat low. The manganese content appeared to be satisfactory for an acid soil but it was thought that, in some cases at least, this element might become deficient if too much lime were applied.

*Soil Phosphorus.*—In connection with an examination of soil samples from a potato experiment, some information was required on the effect of applied phosphorus on that fraction determined as readily soluble. A composite sample was divided into several parts and phosphorus in the form of monocalcium phosphate was applied at four different rates. The soil was kept moist in the laboratory for six months and, after drying, the phosphorus was extracted (*a*) by sodium acetate solution at pH 4·85 and (*b*) by ammonium sulphate solution at pH 3·0. Where phosphorus was applied, the amount extracted was increased but, in each case, this was less than the amount added to the soil. This indicates that, with the soil under investigation, a considerable amount of the added phosphorus is fixed in the soil and is not readily soluble in the extractants used.

*Soil Mineralogy.*—Two soils from Ontario and one from Saskatchewan were separated into sand, silt and clay fractions using a standard centrifuge and a sedimentation procedure. The sand fractions were separated into four specific gravity groups, using mixtures of tetrabromoethane and nitrobenzene. These fractions were studied petrographically for the mineral contents and an approximate percentage value was worked out for each fraction. Results indicated that the Saskatchewan sample contained relatively greater amounts of zircon, opaque, epidote and orthoclase than the other two and also considerable quantities of chlorite and biotite which were absent in the others.

Dehydration curves for the clay fractions of the same three soils were determined and compared with standard curves for the minerals montmorillonite, kaolinite and illite. The curve for the Saskatchewan sample resembled that for montmorillonite while that for one of the Ontario samples (North Gower clay) resembled the illite curve. The curve for the third sample (Rideau clay) did not resemble any one of the three standard curves very closely.

An examination of the clay fractions of the three soils under consideration by means of the electron microscope was made by the National Research Council on request. The most prevalent clay mineral appeared to be kaolinite, crystals of which were observed in all the soils.

*Methods of Analysis.*—In the determination of phosphorus by the molybdenum-blue colour reaction, an error may be introduced if arsenic is present because the arsenate ion gives the same colour as the orthophosphate ion. In determining the readily-soluble phosphorus of soils extracted with a sodium acetate solution, it was found desirable to ensure that arsenic did not interfere. Based on information available in the literature, the development of details of a satisfactory method has been completed.

In the determination of potassium in sodium acetate extracts of soil as a measure of its availability to plants, the procedure has been to determine the density of the cobaltinitrite precipitate visually. Some workers have suggested stabilizing the precipitate by means of a protective colloid, thus permitting density readings to be made in a photoelectric colorimeter. A considerable amount of work was done in this laboratory in establishing the proper details for the new procedure and determinations of potassium by the modified method are now being done satisfactorily.

In highly coloured soil extracts, it was found impossible to determine nitrates directly by the phenoldisulphonic acid colour reaction. Attempts to remove the colouring matter by oxidation or absorption were not successful. Details of a procedure were worked out whereby the nitrate is reduced to ammonia by Devarda's alloy, then steam distilled into hydrochloric acid solution and determined colorimetrically, using Nessler's reagent. The recovery of nitrates from coloured solutions and from standards has been found satisfactory.

In the determination of acid-soluble phosphorus in soils, it is believed that at least a portion of the extracted phosphorus is reprecipitated, especially if sesquioxides are present, forming insoluble iron and aluminum phosphates. The use of 8-hydroxy-quinoline has been suggested to tie up the iron and aluminum. In this laboratory, attempts were made to use this material in sodium acetate extracting solution at pH 4·85 but it was found difficult to maintain the reaction and concentration where this substance was present. As a result of a considerable amount of investigation, it was found possible to mix the material thoroughly with the soil before extracting the latter with the sodium acetate solution. With 30 soils, varying in texture from sands to clays and in reaction from pH 5·8 to pH 8·3, the soluble phosphorus was greater in all but one case when the 8-hydroxy-quinoline was used, although the amount of increase varied with the soil.

*Soil Reaction.*—Laboratory and greenhouse experiments were carried out to determine the effect of sulphur in reducing the reaction of strongly alkaline soils. Samples from four soil types which together make up approximately 24 per cent of the soils in Carleton county, Ont., were used. The reactions of these samples varied between pH 7·7 and pH 8·2. Treatments included sulphur at 300, 600 and 1,200 lb. per acre and gypsum at a rate that supplied sulphur at 600 lb. per acre.

On three of the soil types the treatments caused little change in soil reaction. On the fourth there was a marked reduction in pH value of the soil where sulphur was applied at 1,200 lb. per acre. No significant yield differences in oats and alfalfa resulted from any of the treatments.

*Esminel.*—Esminel is the trade name of a product containing several of the minor elements, boron, copper, zinc, iron and manganese, and is designed to be used as a soil treatment. In 1946 and 1947, this product was used with tomatoes but no beneficial effect on either yield or quality (amount of marking or cracking of fruit) was obtained. In 1948, the material was used on several vegetable crops (carrots, beets, onions and beans) and again no beneficial effect was obtained.

*General Fertility Studies.*—Co-operative studies with the Horticultural Division of the Experimental Farms Service included the examination of (1) 18 soil samples from the Smithfield (Ont.) black currant mulch plots, (2) 41 samples from the Smithfield vegetable rotation plots, (3) 23 samples from the Pine Grove area on the Central Farm, Ottawa, and (4) 21 samples from the N.O.A. Variety Orchard, also on the Central Farm at Ottawa.

Studies in connection with soil fertility experiments conducted in co-operation with the Division of Field Husbandry have been continued at the branch stations at Charlottetown, P.E.I., Nappan, N.S., Ste. Anne de la Pocatiere, Que. Kapuskasing, Ont., and the Central Farm at Ottawa.

*Soil Survey.*—During the year, in co-operation with soil survey officials, a considerable amount of work was done on an investigation dealing with soil formation and development. This involved a detailed study of sixty samples from six selected soil profiles in Ontario and Quebec.

*Advisory Service.*—A total of 683 samples of soil, 5 samples of peat, 3 samples of limestone and 4 samples of manure were received for examination from farmers, gardeners and others interested in agriculture. Reports as to general fertility and recommendations in regard to the use of fertilizers were made. The total number of samples examined was 50 per cent greater than in the previous year.

## Branch Laboratories

### KENTVILLE, N.S.

*Food Products.*—Examination of products under the Fruit, Vegetables and Honey Act comprised dehydrated apples, canned pumpkin, pickles, sauerkraut, jams, apple juice and concentrate. The volume of samples from the dehydrating plants was less than in previous years due to the smaller apple crop. The quality of the product, however, was excellent. In the past two seasons there has been a tendency toward higher acidity of apples grown in the province than had been the case in former years. Investigations are in progress to determine cause of darkening of ciders held in storage.

*Orchard Investigations.*—Studies are in progress toward the determination of the relationship of chlorophyll and magnesium content of apple leaves to mite infestation of orchards.

The persistence of arsenical combination sprays, DDT and parathion was determined throughout the growing season, and also the residual deposits on fruit at harvest. The newer spray material, parathion, "weathers" quite rapidly. The residue found bears some direct quantitative relationship to the rate and number of applications.

### SUMMERLAND, B.C.

*Mineral Nutrition (Boron).*—The soils of the Okanagan Valley of British Columbia are fundamentally deficient in boron and although recommendations for the application of boric acid to all cultivated land were made in 1935-36 there are still many unsolved problems with respect to this element. The boron requirements of stone fruits and of vegetables are not known. The holding powers of different types of soils for boron under various cultural and irrigation practices

have not been determined. In order to investigate these problems, chemical analyses were made on tissues from peach, cherry, apricot, and prune trees, and from carrot plants so that the amount of boron associated with healthy growth would be known. Boron deficiencies were noted in a few samples of cherry- and peach-tree tissues. In several instances excesses were found in peach-tree tissues. These deficiencies and excesses were correlated with the amount of boron present in the soil on which the trees were growing. In carrots, it was shown that when the roots contained 43 p.p.m. boron on a dry-weight basis the plants were more resistant to bacterial blight (*Xanthomonas carotae*) than when roots contained only 19 p.p.m. boron on a dry-weight basis.

*Chlorosis in Fruit Trees.* — Field studies on chlorosis were continued. Experiments consisted of (*a*) placing ferrous and ferric salts in gelatine capsules into holes drilled in trunks of affected trees, (*b*) treating soil with either a 10 per cent solution or with solid ferrous sulphate, and (*c*) spraying trees with a one per cent solution of iron carbamate (ferric dimethyldithiocarbamate). Partial control was obtained in some of the treated trees but because of the abnormally wet season the results are difficult to evaluate accurately.

*Insecticides and Fungicides.*—Studies on high-speed concentrate sprayers were continued in three separate investigations with special attention to the uniformity of deposits.

Oil deposits in dormant spraying were determined on apple twigs from tops and bottoms of trees sprayed (*a*) by hand, (*b*) by a commercial high-speed sprayer, (*c*) by the hydraulic and (*d*) by the steam generator unit of the Okanagan experimental sprayer, developed at the Summerland Entomological Laboratory. Coverage on tops of trees was equally as satisfactory as with hand spraying. Since there is no wasteful "run-off" with the concentrate sprayers it should be possible to reduce the per acre dosage of toxicant below that used in conventional hand spraying.

To determine the efficiency of high-speed sprayers when the trees were in foliage, DDT was determined in spray deposits on apple leaves from tops and bottoms of trees sprayed (*a*) by hand and (*b*) by a commercial high-speed sprayer. Deposits were more uniform from hand spraying than with the high-speed sprayer.

DDT deposits on apples at harvest were determined. Samples were taken from tops and bottoms of trees to determine the uniformity of deposits. The hand-sprayed plots had more uniform deposits than any of the plots sprayed by high-speed machines.

Parathion residues on apples were determined to investigate the amount of insecticide present on the fruit at the time it is shipped to market.

Methods were developed for analysing light orchard spray oils. This makes it possible to classify oils on the basis of types of hydrocarbons present. Classification of spray oils by this system is more satisfactory than the present physical classification since the behaviour of oils in insecticide sprays is more closely related to the chemical than to physical properties.

*Fruit and Vegetable Products.*—Some 897 samples of food products submitted by Marketing Service Inspectors were analysed to assist in establishing grades and controlling the quality of processed materials. A limited service was given to the Experimental Farm Fruit and Vegetable Products Laboratory and to the Canned Foods Association of British Columbia.

### SAANICHTON, B.C.

*The Nutrition of Phytophthora Species.*—The essential nutrients were determined in 1947 and the study was continued to establish optimum levels and kinds of sugar for four species of *Phytophthora*. Maximum growth occurred at

4 per cent concentrations of glucose or sucrose. The coefficients of utilization were independent of the sugar concentration or the kind of sugar. The nitrogen requirements of *Phytophthora parasitica* were investigated with a view to developing a suitable medium for the microbiological assay of thiamin. With amino nitrogen supplied at a constant level by 1 per cent alanine, growth when plotted against thiamin concentration gave a straight line between the limits of 0·2 and 0·6 mg. of thiamin per liter. It would appear that *P. parasitica*, when used under the conditions established at Saanichton, has considerable value as a test organism for the estimation of thiamin.

*The Fungistatic Values of Dithiocarbamates against Phytophthora Species.*—The fungistatic effects of six dithiocarbamates were tested against four species. Manganese ethylene dithiocarbamate was the most effective followed by the manganese dimethyl and iron dimethyl salts in descending order. The manganese and iron dimethyl dithiocarbamates were much more effective against *P. cactorum* than against the other species.

*The Fungistatic Values of Metal Precipitating Organic Compounds.*—Eight compounds used in analytical chemistry were tested against *P. erythroseptica* using copper sulphate as a standard. Three of the compounds, cupferron, phenylthiohydantoic acid and salicylaldoxime demonstrated appreciable fungistatic properties. They have the disadvantage, however, of high solubility.

## DIVISION OF ENTOMOLOGY

### Field Crop Insect Investigations

The major activities of the Field Crop Insect Investigations in 1948-49 fell into two groups: the use of the new organic insecticides and the development of insect-resistant plants. Associated with these studies and of paramount importance to them was a marked increase in studies on the biology of the insects. These include detailed investigations on behaviour, nutrition, effects of temperature and moisture, and reaction to the environmental complex, both in the laboratory and in the field. Increased attention has been given to the study of the newer materials which show promise in the control of soil-infesting insects and nematodes. In addition to the usual inquiries regarding information on insects, all field laboratories have received many requests for information on the new insecticides, which are reported in the press or are advertised as "cure-alls", frequently before sufficient research has been carried on to determine their real value.

Though grasshoppers are most troublesome as economic pests in the Prairie Provinces and British Columbia, in 1948 an outbreak of the red-legged grasshopper occurred in southeastern Ontario and southern Quebec; but it occurred so late in the season that there was very little crop damage. The outbreak of the clear-winged and lesser migratory grasshoppers in the Prairie Provinces was the most severe in the last ten years. As a result of extensive field experiments, it was recommended that either chlordane or toxaphene be used to replace arsenicals and fluosilicates, which are more toxic to warm-blooded animals. These new insecticides were used as sprays, as dusts, or in poisoned bait and provided a quicker and more effective control. Studies on grasshopper behaviour and nutrition have provided information leading to a more effective use of control measures and the possibility of producing grasshopper-resistant cereals.

In a serious and unexpected outbreak of grasshoppers in eastern Ontario and western Quebec, migrations of these insects into vegetable and ornamental crops occurred, causing extensive losses. At the St. Jean laboratory, south of Montreal, field experiments were carried out to test the effectiveness of chlordane sprays under eastern conditions. Excellent results were secured by applying

the insecticide as an emulsion to the foliage at one pound of actual chlordane per acre, including the area immediately surrounding the gardens. Furthermore, the poison retained its toxicity for two to three weeks, greatly reducing the number of applications.

The losses caused by the wheat stem sawfly are being greatly reduced by the increased use of the sawfly-resistant spring wheat, Rescue, which was developed in a co-operative investigation by the officers of the Dominion Entomological Laboratory at Lethbridge and the Dominion Experimental Station at Swift Current. Investigations on the nutrition of the sawfly larvae are being carried on to assist in the development of better quality wheats which will be even more resistant than Rescue. Biological studies have shown that if the season is unfavourable for plant development, the sawfly larvae are also affected and will continue in a dormant condition until the next spring without any appreciable mortality or loss of vigour.

Experiments conducted at the Dominion entomological laboratories at Saskatoon, Sask., Victoria, B.C., and Chatham, Ont., have shown that benzene hexachloride applied either directly to the soil or as a seed dressing provides an excellent control for wireworms. However, the disagreeable odour of this insecticide taints most root crops and greatly limits its use. Chlordane and ethylene dibromide appear to provide as good control as benzene hexachloride without tainting the plants. DDT worked into the soil appears to be a very effective control for wireworms over a period of years, but its slow action will not provide crop protection the first year it is used.

The examination of plots which were sprayed with DDT and benzene hexachloride to destroy June beetles emerging from the ground has indicated that beetles digging into the soil to deposit their eggs may have been destroyed by the spray residue. First-stage larvæ were far less plentiful in the treated plots than in the untreated ones. A study of the pH of soils infested by white grubs indicates that irrespective of sod conditions the beetles apparently prefer acid soils when ovipositing.

Investigations on the European corn borer at Chatham and Harrow have shown that the two-generation strain is becoming more abundant in southwestern Ontario and is complicating the control program. Some of the hybrid corn varieties appear rather resistant to attack, and further work is planned to develop a borer-resistant strain of corn.

At the Chatham, Ont., laboratory, investigations on the European clover seed weevil have proved that this insect is responsible for much of the reduction in alsike clover seed production. The yield of alsike seed is more or less directly proportional to the beetle population. Reductions in the numbers of beetles and very marked increases in yields of alsike seed have been secured by dusting or spraying with DDT or chlordane.

The sweet clover weevil is widespread east of the Rocky Mountains and causes serious losses to sweet clover wherever it is grown. In Manitoba, where sweet clover is an important forage and honey crop, the weevil is a serious economic pest. Biological studies on this insect showed that in some seasons a large majority of the immature stages are destroyed by a fungous disease, *Beauvaria bassiana*, and by heat and desiccation. The adults can be controlled by spraying with DDT or chlordane, and since they feed most heavily on seedling sweet clover, chlordane may be used without danger of destroying honey bees.

In 1948, tobacco in southwestern Ontario was severely damaged by an unprecedented outbreak of the green peach aphid. Severely infested tobacco plants were damaged by the insects feeding on them, and the quality of the tobacco was reduced by the deposits of honey-dew excreted by the aphids, as well as by the accumulations of cast skins which adhered to the leaves. Sprays

and dusts of nicotine sulphate, rotenone, and DDT gave moderate control of the aphids, but parathion gave the best results. The latter insecticide is extremely dangerous to handle and is not registered for sale in Canada. Studies were started to determine the life-history of the insect on tobacco.

Turnip maggot investigations were continued in Ontario and the Maritimes. The life-history of the maggot was worked out under field conditions. The most promising of the older remedies were retested and the effect of the newer insecticides on different stages of the insect was studied. A 5 per cent chlordane dust was the most effective but resulted only in a 50 per cent control. DDT was relatively ineffective. Benzene hexachloride caused a tainting of the roots.

Studies on the biology and control of the carrot rust fly were continued at Agassiz, B.C., Bradford, Ont., and Mount Pearl, Nfld. At Bradford, a turbine duster was used in an attempt to eliminate the flies over large areas before any eggs were laid, using a 3 per cent DDT dust. Results were inconclusive. In other control experiments, a 5 per cent chlordane dust gave best results and will be recommended for use, tentatively, in 1949. Benzene hexachloride, which has proved so promising in British Columbia, caused severe tainting of the carrots in treated plots at Bradford.

Studies on the onion maggot were continued at different points across Canada. In studies at Ottawa on varietal resistance to maggot attack, the most resitant variety, Brown Australian, showed a 10 per cent mortality and the most susceptible one, 18 per cent. Whether such resistance can be utilized commercially remains to be proved. In chemical control experiments, chlordane when applied to the seedlings and soil as a 5 per cent dust showed the greatest promise.

Studies on the biology and control of the onion thrips in southwestern Ontario show that either DDT or chlordane dust properly timed and carefully applied will give excellent protection. Chlordane appears the more promising, but there is still some doubt that it can be used under all conditions without tainting the bulbs.

In 1947 and 1948, devastating outbreaks of the corn earworm occurred in the Maritime Provinces. The insects confined their attacks to sweet corn, which, particularly in 1947, was rendered unfit for market over extensive areas. In field experiments at Fredericton, using derris, DDT, ryania, and rhothane, the application of rhothane, either as a dust or as a spray, to the silks during the egg-laying period gave fairly good protection.

Preliminary investigations were conducted at Woodstock, N.B., to ascertain whether or not the hydrogen-ion concentration of the cell sap has a bearing on the speed of wing development in potato aphids. During the season the hydrogen-ion concentration varied considerably in different tissues of the plants of the same variety. Results to date support the theory that there is a correlation between the degree of sap acidity and aphid resistance and also that this factor has a bearing on wing development.

Field experiments in New Brunswick on different insecticides for potato aphids showed that: (*a*) all-season spraying at weekly intervals with DDT emulsion (1½ pints 25 per cent emulsion in 100 gallons) almost eliminated all species on potatoes; (*b*) spraying from mid-August to mid-September, or throughout August, gave equally good control; (*c*) applications before August gave significant control; (*d*) applications of a 2 per cent parathion dust at weekly intervals completely controlled potato aphids; (*e*) a 1 per cent parathion dust applied at weekly intervals proved fairly effective but did not give so great a mortality as the higher concentration.

Studies were begun on the biology of a root webworm, which seriously damaged field and garden carrots in the St. Jean, Que., district.

Studies at Brandon, Man., and Bradford and Ottawa, Ont., showed that DDT residues on celery treated for the control of tarnished plant bug were well

below the tolerance, and experiments at Ottawa showed that tubers from a potato patch sprayed through the season with parathion at recommended strength failed so show a trace of this chemical.

### Fruit Insect Investigations

In British Columbia, work was continued with high-speed concentrate sprayers in experiments designed to eliminate hand spraying. Basis of the work was the operation of the Okanagan experimental sprayer, a machine designed at the Entomological Laboratory, Summerland, B.C., and built by the Defence Research Station at Suffield, Alta. The steam and hydraulic units of this machine each controlled mildew on apples to about the same extent as hand spraying. A commercial concentrate trailer-blower was evidently as effective as hand spraying for San Jose scale control in the dormant period. Three concentrate machines (two of them commercial adaptations of the Okanagan experimental sprayer) gave almost as good control of pear psylla with nicotine sulphate as did very thorough and heavy hand spraying with the same insecticide at approximately the same dosage per acre. Further experiments showed that two of these machines were also very effective for summer control of codling moth and European red mite. Chemical analyses of oil deposits revealed that both the trailer-blower and Okanagan experimental sprayer applied sprays very uniformly in the dormant period. Spray deposits in the tree tops were almost as heavy as deposits on the lower branches, but deposits with hand spraying were often much lower at the tops than at the bottoms. Average deposits with concentrate machines were higher than those with hand spraying although dosages per acre were similar. Concentrate machines did not give a very uniform deposit on large apple trees in full foliage, the deposits at the tops being lower than with hand spraying and those on the bottoms higher. Though high-speed concentrate sprayers may not give quite so effective pest control as very thorough hand spraying, they will probably do a better job than the average man with a hand gun, and at the same time effect a saving in labour costs of up to 90 per cent. Commercial machines designed after the experimental models are already in production.

The long-term studies of the effects of spray materials on the orchard fauna were continued in Nova Scotia and Ontario. In the former province, further evidence was accumulated on the deleterious effect of sulphur fungicides on the biological agencies which normally suppress many apple pests. That sulphur induces outbreaks of oystershell scale and European red mite was definitely proved, and there is now some evidence that codling moth infestation may be intensified by this fungicide. In Ontario, very heavy infestations of European red mite have invariably followed the use of DDT for oriental fruit moth control on peaches, because of the virtually complete destruction of predators. Predation on the over-wintering eggs in late summer and autumn has been found to be very important in reducing the following season's infestation; where DDT is employed this predation is never extensive.

The control of European red mite and related species is still the most urgent problem in orchard pest suppression in Canada. In British Columbia dormant applications of lime sulphur, 4 gallons, plus heavy dormant oil (220 Vis.), 2 gallons per 100 gallons, generally controlled European red mite until after the first DDT codling moth cover spray. Where the dormant spray was not applied it was necessary to commence spraying for mites at the time of the first cover spray. Sprays of 15 per cent parathion, 8 ounces, or potassium ammonium selenosulphide, 2 quarts per 100 gallons, at the pink stage were more effective than a dormant spray of lime sulphur-heavy dormant oil. In fact, plots which received these materials at the pink stage required no further mite sprays. Monoethanolamine dinitrocyclohexylphenolate did not control European red mite when applied at the pink stage, probably because of prevailing cool weather.

Parathion was the most effective of all materials tried for summer control of mites. When used with DDT in the first 3 cover sprays at 8 ounces of 15 per cent wettable powder per 100 gallons, it gave practically 100 per cent control of European red mite, Pacific mite, and all aphids. No foliage or fruit injury occurred. Concentrations lower than 8 ounces did not give adequate control. Parathion is favoured as a miticide because it not only gave excellent control of European red mite and Pacific mite but also gave good control of most aphids, showed promise for control of blister mite, rust mite, San Jose scale, and oyster-shell scale, probably helped in control of codling moth, and also gave exceptional control of pear psylla. Furthermore, it is unlikely to cause so much injury as the currently recommended miticide, monoethanolamine dinitrocyclohexylphenolate, when applied by high-speed concentrate sprayers. Diparachlorophenylmethyl carbinol (DMC) at 1 pound of 25 per cent powder per 100 gallons in 3 cover sprays with DDT gave very good control of European red mite and caused no fruit or foliage injury but was slightly inferior to parathion. As DMC does not control aphids, it probably would have to be supplemented with an aphicide if used in a mite spray program. Both 75 per cent lauryl, 2-thiazolinyl sulphide, 1 pint, and 40 per cent di-(4-chlorophenoxy) methane, 1·25 pound per 100 gallons in 3 cover sprays, gave as good control of European red mite as DMC but, like DMC, were not effective against woolly apple aphid. Unlike DMC, both of these materials caused fruit or foliage injury. Forty per cent tetraethyl pyrophosphate, 0·5 pint per 100 gallons, gave a high immediate mortality of European red mite but its residual action was rather low. It injured the foliage of some varieties of apple and in some cases seriously blemished the fruit of pear. The currently recommended miticide, monoethanolamine dinitrocyclohexylphenolate, usually was effective. The few disappointments experienced with this compound were no doubt due in part to the exceptionally cool, wet weather during the past season. This material definitely should not be used until 4 weeks after the calyx stage on pears and until 2 weeks after the calyx spray on apples because of the risk of fruit and foliage injury on pears and foliage injury on apples. The monoethanolamine salt of 2,4-dinitro-o-secondary-butylphenol at 2 ounces of the active material per 100 gallons gave excellent control of European red mite but caused serious fruit and foliage damage. Four scab sprays of lime sulphur, 1·5 gallons per 100 gallons, when thoroughly applied gave excellent control of European red mite throughout the season. Iron carbamate-wettable sulphur sprays for scab exhibited no miticidal value.

In Ontario, parathion added to the third and fourth cover sprays on apple gave better control of European red mite than any other material tested, reducing the population to such an extent that no later build-up occurred. A 3 per cent oil emulsion at the delayed dormant stage effectively delayed the seasonal build-up of the mite, although the final infestation in the oil plot equalled that of the check by early September. Two applications of parathion, at the shuck stage and 12 days later, gave excellent control of red mite on plum. Di-(para-chlorophenoxy) methane applied at the same time was also very effective in preventing injury during the rest of the season. For the second year, summer oil failed to give adequate control in two out of three plots.

In combating heavy mite infestations on peaches induced by the use of DDT in Ontario, the dicyclohexylamine salt of dinitrocyclohexylphenol was more effective than di-(parachlorophenoxy) methane, although one application of either was not sufficient to hold the severest outbreaks in check.

In Quebec, parathion and the monoethanolamine salt of dinitro-o-cyclo-hexylphenol gave good results against the European red mite, a single application of either material preventing serious injury to apples for the rest of the season.

Of a considerable number of new miticides tested in Nova Scotia, parathion appeared most promising when safety to foliage, absence of fruit russetting, and

control of mites were considered. Some other materials gave better mite control but were inferior in other respects.

In the Okanagan Valley of British Columbia three sprays, spaced about 2 weeks apart, of a DDT-stove oil formulation applied at about 28 pounds of 50 per cent DDT per acre gave good control of codling moth. Conventional hand guns were evidently as effective as the Okanagan experimental sprayer (hydraulic or steam unit). In the Kootenay area, 4 applications of cryolite at 2 pounds per 100 gallons gave good control. Four sprays of calcium arsenate at 4 pounds per 100 gallons were not so effective as cryolite, and 4 DDT sprays at 1.5 pounds of 50 per cent per 100 gallons were somewhat better than cryolite. DDT does not seem to be urgently needed for codling moth control in this district, since cryolite so far has given reasonable control and has not aggravated the mite problem.

In Ontario, 4 cover sprays of DDT or 5 covers consisting of DDT alternated with lead-oil gave markedly better results against codling moth on apples than lead arsenate alone but failed to give commercial control where adjacent orchards were unsprayed or poorly sprayed. In a semi-isolated orchard, 5 cover sprays of DDT applied 2 years in succession have reduced deep injury to 1 per cent. Parathion in 4 cover sprays compared fairly well with DDT but caused some injury to fruit and foliage at the first cover. On pears, DDT in 2 cover sprays was more effective than either parathion or lead arsenate-summer oil.

Although the 1948 infestation of oriental fruit moth was the heaviest ever experienced in the Niagara Peninsula, DDT sprays applied in July prevented much of the injury to peaches caused by second-brood larvae which leave the twigs and attack the fruit, 2 applications being somewhat better than one. The spray applied 6 weeks before harvest of late varieties afforded very little additional protection and increased the residue hazard. The spray 3 weeks before harvest continued to give good protection against late entries in Elberta, but as applied by growers it was apparently not so effective on some midseason varieties. In 1949, 3 sprays, including 2 in July, will be recommended for late varieties, including Elberta, and 1 and 2 sprays, respectively, for early and mid-season varieties. To avoid excessive DDT residue on harvested fruit, it has been necessary to reduce the concentration of the last (three-weeks) application from 2 to 1½ pounds of 50 per cent powder per 100 gallons. The great importance of very thorough spraying was demonstrated. Parathion tested on a small scale gave conflicting results, being apparently much more effective against the second brood than the third.

In British Columbia, dormant applications of lime sulphur plus heavy dormant oil were most effective against San Jose scale. Good control was obtained either by hand spraying with lime sulphur, 4 gallons, plus dormant oil, 2 gallons per 100 gallons, or by spraying with a suitable commercial type trailer-blower using a 5-times concentrate, i.e., lime sulphur, 20 gallons; dormant oil, 10 gallons per 100 gallons. Parathion applied at the dormant period, at a rate equivalent to 2 pounds 25 per cent wettable powder per 100 gallons, did not give satisfactory scale control.

Several insecticides were applied by the conventional hand gun and by various high-speed concentrate sprayers for summer control of pear psylla in British Columbia. Parathion, whether applied in the conventional manner or by concentrate sprayers, at about 7.5 pounds of 15 per cent material per acre, gave good control of psylla. Chlorinated camphene (Toxaphene) at about 30 pounds of 25 per cent material per acre, was not quite so effective as parathion. The standard summer treatment of nicotine sulphate-summer oil was slightly inferior to chlorinated camphene. A pyrethrum concentrate, used without oil, did not give satisfactory results. A tetraethyl pyrophosphate formulation resulted in high psylla mortality but caused foliage and fruit in ury.

In Ontario, a dormant spray of sodium dinitrocresylate was inferior to the standard dormant oil emulsion, allowing psylla to build up later in the season. Among summer treatments parathion was outstanding. Summer oil-benzene hexachloride also gave good control and oil-nicotine was slightly inferior. Insectary experiments showed that parathion was lethal to all stages of the psylla, including the eggs, at low concentrations. This material produced no foliage or fruit injury on Bartlett or Kieffer but injured some other varieties slightly.

Delayed dormant sprays of benzene hexachloride-heavy dormant oil (220 Vis.)-Velsicol (a methylated naphthalene), benzene hexachloride-distillate oil (38 Vis.)-Velsicol, and lime sulphur-heavy dormant oil, all proved effective against peach twig borer in British Columbia, but were not so good as the recommended treatment of lime sulphur, 10 gallons per 100 gallons at the pink stage of bud development. Sprays of 50 per cent DDT, 2·5 pounds per 100 gallons, gave better control than lime sulphur at the same period. Limited evidence indicates that parathion applied at the pink stage is comparable with DDT.

Delayed dormant sprays of 15 per cent parathion, 1 pound, or gamma benzene hexachloride, 0·25 pound per 100 gallons, gave as good control of black cherry aphid in British Columbia as the current recommendation of 40 per cent dinitrocyclohexylphenol, 1·5 pounds, when all were used in 1 per cent heavy dormant oil emulsion. Delayed dormant sprays of parathion-dormant oil or gamma benzene hexacholride-dormant oil, were also very effective against mealy plum aphid and hop aphid.

In both British Columbia and Ontario, summer trunk sprays of DDT were inferior to fall treatments of paradichlorobenzene, ethylene dichloride, or propylene dichloride for control of peach-tree borer. In both districts many larvae require more than one season to complete development; hence, effective control with trunk sprays may be possible only when they are applied for two consecutive years.

Summer sprays of parathion directed against young eye-spotted budmoth larvae on the foliage were very effective in both New Brunswick and Nova Scotia, and in the latter province dormant applications of this material also gave excellent control of hibernating larvae at relatively low concentrations.

In Nova Scotia, parathion gave outstanding control of grey-banded leaf roller, being decidedly better than the currently recommended lead arsenate, which does not always give dependable results.

In British Columbia, various DDT-stove oil formulations applied with the Okanagan experimental sprayer, at about 6 pounds actual DDT per acre, reduced "catfacing" of peaches caused by plant bugs in 5 of the 7 treated orchards. Two sprays, the first at petal fall and the second at shuck fall, were no more effective than the single application at petal fall. Pink sprays were not so effective as sprays at petal fall.

Investigations on the control of the currant fruit fly in Manitoba showed that one pre-blossom and two post-blossom sprays of DDT will reduce the injury, although it will probably be necessary to continue this treatment for several years to eliminate infestations. The 3-spray DDT program did not leave excessive residue on the fruit. Chlordane gave poorer control than DDT, and benzene hexachloride was quite ineffective.

For the second season, sodium dinitrocresylate preparations were the best of the dormant applications tested for oystershell scale in Ontario, although dormant oil emulsion was also effective. Comparable results were obtained in New Brunswick. The oil is apparently preferable because it is cheaper and does not induce the outbreaks of European red mite which often follow the use of dinitrocresylates. Among summer treatments at the calyx stage, parathion was best and also suppressed European red mite and white apple leafhopper. DDT gave nearly as good control but unless it was used with an acaricide severe red mite infestation resulted.

In the 1948 tests, parathion was superior to other materials for the control of cranberry fruitworm in New Brunswick. DDT emulsion was also fairly effective, but contrary to previous years' results, DDT dust did not give so good control as the standard cryolite dust.

DDT continued to give best control of strawberry weevil in New Brunswick, sprays and dusts being approximately equally effective this season. Parathion did not give so good results as DDT, and as in the 1947 tests, benzene hexachloride and toxaphene afforded little if any control.

In British Columbia, results of the past season's experiments substantiate previous reports that very promising control of white grubs, the larvae of the June beetle *Polyphylla perversa* Csy., may be obtained from a number of soil insecticides. Both benzene hexachloride at 1 to 1·5 pounds gamma isomer and chlordane at 1 to 2 pounds per acre, applied in October, 1946, protected strawberry plants throughout 1947 and 1948. Ethylene dibromide and dichloropropane-dichloropropylene (D-D) mixture did not appear to be effective for more than one year. None of the treatments injured the plants and D-D mixture and ethylene dibromide had a pronounced stimulating effect. No tainting of strawberries was produced by benzene hexachloride. Limited tests with methyl bromide-ethylene dichloride mixture and ethylene dibromide to control two-year-old grubs attacking first-year strawberry plants indicated that each of the materials was very effective when injected near the plants. The methyl bromide-ethylene dichloride mixture did not cause any plant injury at the highest rate tested.

For the second year, 3 per cent DDT dust applied twice before blossoming gave the most effective control of western raspberry fruitworm on loganberries in British Columbia. Growers who tried this treatment were highly pleased with the results, their crops selling at a premium because of freedom from worms.

The leafhopper *Typhlocyba tenerrima* H.-S., an insect recently introduced to North America, is causing extensive damage to the foliage of loganberry, raspberry, and blackberry in coastal British Columbia. It was effectively controlled by single sprays of either DDT or parathion.

Parathion was highly effective in the control of plum curculio in a preliminary test in Ontario this past year.

Insecticide research in the laboratories in Ontario and New Brunswick was largely concerned with parathion, which has proved to be one of the most potent insecticides for a wide range of insects, including several which were effectively controlled by DDT or other materials. Unlike most synthetic insecticides, parathion was also very effective against orchard mites for which a satisfactory control has long been sought. It may kill by contact, ingestion, or fumigant action. Like other insecticides with pronounced fumigant action, its toxicity is somewhat reduced in moving air. Parathion residues on foliage are considerably less lasting than those of DDT, their effectiveness against most insects dropping rapidly after about a week. Parathion is compatible with most spray materials, including hydrated lime. Bordeaux had no apparent effect on the immediate toxicity but reduced the residual toxicity considerably.

Under some circumstances, certain plants may absorb appreciable amounts of parathion from the soil, sometimes sufficient to render them toxic to insects, but if parathion is used with reasonable care there does not appear to be much danger that fruits or vegetables will absorb enough from sprays or dusts to make them hazardous to human health. The fact that it is very poisonous to higher animals, including man, forms the chief obstacle to its general use.

Investigations to determine whether two important virus diseases of stone fruits are transmitted by insects were continued during the year. The diseases concerned are little cherry, which is very destructive to sweet cherries in the Kootenay Valley of British Columbia, and yellows of sour cherry in Ontario. Conclusive proof that insects are vectors of the viruses has not been obtained, but much information has been secured on the fauna of cherry orchards.

## Forest Insect Investigations

During 1948-49, following a policy of long standing, research on forest insects has been directed mainly towards the development of a better understanding of the causes and conditions governing the rise and fall of destructive outbreaks. This method of approach to forest insect problems has been adopted because it is realized that control measures applied without this knowledge are a wasteful, hit-or-miss procedure likely to produce results more harmful than beneficial.

Several problems affecting the national economy in various degrees were the subject of intensive investigations. The spruce budworm outbreak in Eastern Canada, with its somewhat less important counterpart in the Prairie Provinces and British Columbia, continued to be the outstanding problem. The larch sawfly was present throughout the range of its food plant, but attained destructive proportions only in western Ontario and in Manitoba. The so-called dieback of birch, which may or may not be due to insects, has spread from the Maritime Provinces and Quebec into some areas of Ontario. The native elm bark beetle, carrier of Dutch elm disease, was abundant in infected areas and undoubtedly contributed materially to the spread of the disease. The lodgepole needle miner infestation in the Banff National Park showed an alarming increase in intensity and extent, constituting a serious potential menace to the water supply of the Prairie Provinces.

Facilities for field and laboratory research were materially improved during the past year. Important additions were made to the scientific equipment at various research centres. Construction of the new laboratory of insect pathology at Sault Ste. Marie is proceeding and it is expected that the building will be ready for occupancy before the end of 1949.

Permanent field stations are now established at Green River, N.B.; Laniel, Que.; Chalk River, Ont.; Black Sturgeon Lake, Ont.; Red Lake, Ont.; Whiteshell, Man.; Kananaskis, Alta.; Trinity Valley, B.C.; and Cowichan, B.C. These stations are being developed as strategic centres for the continuous study of forest insects in regions of greatest economic importance. They will provide indispensable information on the biology, ecology, and epidemiology of forest insects under both endemic and epidemic conditions. These findings will be supplemented by and integrated with controlled experiments carried on in the regional laboratories. Forest insect rangers, assigned to remote districts, are being provided with small cabins as summer headquarters. This greatly increases their efficiency through the elimination of much travel from region to region and is an important contribution to good morale.

A new Forest Insect Survey centre was established at Kananaskis, Alta. The territory assigned to it includes the Banff, Kootenay, Yoho, and Jasper National Parks, the eastern slope of the Rocky Mountains, and the northern part of Alberta. The Survey for British Columbia, formerly centred at Vernon, has been divided into two sections. The interior of the province will be covered by the Vernon laboratory and the coastal region will be served by the laboratory at Victoria.

The number of trained forest insect rangers employed by the Department of Agriculture has been increased to 72. Additional permanent plots for quantitative sampling were established in many regions. The total of collections and reports received from insect rangers and collaborators in all parts of Canada amounted to 24,515, an increase of 8,684 over 1947. This proves that unflagging interest and co-operation are being maintained. The Quebec Department of Lands and Forests has made its usual contribution to the national survey, and valuable assistance was rendered by the Nova Scotia Department of Lands and Forests.

The spruce budworm outbreak which began about 1935 in the Mississagi region of central Ontario has run its course in many of the older areas. In some of these, the food supply has been exhausted; but in others, natural control factors have brought about a decline of the budworm population. Not only do infestations of more recent origin persist but many are increasing in extent and intensity. In Ontario, there was a marked decline in the vicinity of Franz. The infestation encircling Lake Nipigon has spread northward and eastward, and moderate defoliation was observed on Sibley and Black Bay peninsula. West of Lake Nipigon and near Black Sturgeon Lake many trees were killed in 1948. The infested area in the Sioux Lookout and Kenora districts grew in size, and heavy tree mortality occurred west of Lac Seul and north of Perrault Lake. In Quebec, a very serious situation is steadily developing. The epidemic has reached new areas in the Lake St. John and Manicouagan regions, and the Saguenay region is almost completely infested. Light budworm populations were found near Trois Pistoles and Rivière du Loup. The river valleys of the Metis and Grande Cascapedia form isolated centres of medium infestation. The remainder of the Gaspe Peninsula, with the exception of South Gaspe county, shows no centres of severe contamination. In L'Islet county an outbreak is developing, and several stands in the Eastern Townships are lightly affected. The older outbreaks in Laurentide Park, St. Maurice district, the Ottawa Valley, and Temiskaming are still very active. In New Brunswick, the budworm population is still very light, although there has been approximately a fivefold increase in numbers in northern areas where the population density has been highest during the past two or three years.

Methods of measuring spruce budworm populations have been improved and refined as a result of intensive sampling studies carried out simultaneously at the Black Sturgeon Lake and the Green River experiment stations; the former in heavy, the latter in light infestations. In both cases, branch samples taken in different parts of the crowns of selected trees in various types of stands form the principal basis for population estimates; they are supplemented by studies of the quantity of frass dropped by feeding larvae. Data so obtained are used in gauging the progress of infestations, estimating the current degree of hazard, and providing basic material for many other computations of scientific import. Considerable progress has been made notwithstanding the many difficulties arising from the great variability of the forest environment. The correlation between defoliation and density of insect populations at different periods and in different types of trees and stands has been carefully studied.

It has been the general belief for many years that spruce budworm infestations developed most readily in stands containing a high percentage of mature and over-mature balsam fir. Partial confirmation of this theory has been found in the discovery that male flowers, which are most abundantly produced on old trees, have a decided influence on such vital functions of the budworm as egg-laying, overwintering, and feeding. Moreover, since on flowering balsam the amount of current foliage is greatly reduced, defoliation by a given number of larvae will be more severe on flowering than on non-flowering trees. This work has an important bearing on the planning of silvicultural methods for the reduction of spruce budworm hazard. The same is true of the studies of tree mortality in the Mississagi area undertaken in co-operation with the Ontario Department of Lands and Forests. Extensive data have been obtained in connection with this project and their final analysis is nearing completion. Even at the present stage of the study, it appears that many of the time-honoured opinions on susceptibility and vulnerability of spruce-fir stands to budworm attack will need considerable revision.

Deterioration resulting from attack by wood-boring beetles on balsam fir killed by the spruce budworm has been under investigation at Black Sturgeon Lake station. This study has been undertaken to secure reliable data on the

time limit for salvability of timber after the death of the trees. Several species of bark beetles, ambrosia beetles, and sawyer beetles contribute to the decay of these trees. Very valuable information has been obtained for the stands under investigation, but its application to other areas will require further research.

The study of the influence of weather and climate on the behaviour and spread of the spruce budworm was continued at Sault Ste. Marie and was considerably enlarged in scope during the year 1948-49. Preliminary studies give some indication of the possible relation of certain drought periods and storm tracks to the development of infestation centres. Should further investigations confirm the validity of this theory, a very important step will have been taken towards the determination of the primary cause of budworm outbreaks.

It is becoming increasingly evident that the spruce budworm is a heterogeneous species comprising many biological strains and geographical races. It is suspected that this variability may have an important bearing both on the behaviour of the insect and on the trend of infestations. To throw light on this question, cytogenetic studies of budworm populations have been in progress for several years and have led to some interesting results, the most important of these being the now well established differences between true spruce budworm and jack pine budworm not only in form and food preference but also in seasonal and diurnal rhythms. The latter characteristic is of special significance in areas where spruce budworm and jack pine budworm populations overlap, inasmuch as it constitutes an effective isolation mechanism preventing hybridization and the evolution of races possessing a higher destructive potential than the parent strains. It also has some bearing on the nature and timing of control operations.

Insect parasites and disease organisms attacking the spruce budworm received special attention. Activities in the introduction, propagation, and distribution of parasites from British Columbia, the Western United States, and Europe into Eastern Canada are described in another section of this report entitled "Biological Control of Insects". The use of disease organisms in combating insect pests is a comparatively new venture. In Canada, the first successful attempt was made several years ago in the campaign against the European spruce sawfly. In 1946, a search for any promising micro-organisms that might attack the spruce budworm was begun at home and abroad. The first indications of the existence of a native virus were found in Ontario, near Cochrane and Kapuskasing; later similar reports were received from New Brunswick, British Columbia, and the State of New York. In the meantime, several fungi were also discovered. In 1948, a very interesting, new type of virus disease attacking a European fir budworm was found in the Vosges Mountains in France.

All these organisms are now under intensive study at Sault Ste. Marie by a staff of highly-trained specialists, and several small-scale control experiments will be initiated in the near future. At the present advanced stage of the spruce budworm outbreak, the use of some virulent disease offers practically the only hope of arresting the spread of the infestation to new areas. Time will be an important factor in shaping the ultimate fate of the experiment. Though all the above-described studies and procedures are important contributions to the struggle against the spruce budworm and may provide temporary protection, final and adequate control of this pest will probably not be achieved until a vigorously growing forest, scientifically managed to meet the requirements of an expanding civilization, will have replaced the present last remnants of the virgin forests.

The jack pine budworm caused heavy damage in the Kenora and Sioux Lookout districts in Ontario. The points of overlap in the infestations of spruce and jack pine budworms greatly increased in number during the past year. Outbreaks of jack pine budworm gained considerably in extent and intensity in

eastern Manitoba. The outbreak seems to be spreading from adjoining areas in Ontario and occurs in "pockets" over a large region. The most extensive of these pockets was found southeast of Bissett and covers at least one hundred square miles. Until very recently, the jack pine budworm was considered to be identical with the spruce budworm. It is now considered a different species with very distinct life-history and habits requiring special consideration in planning control measures. Intensive studies of its biological characteristics are in progress with this object in view.

The European larch sawfly is again on the increase in several areas. Ever since the disastrous outbreak which swept over Eastern Canada in the early part of the century, and which destroyed practically all the old commercial stands in the region, the new stands which have replaced them have been subject to periodic defoliation, often so severe as to cause considerable alarm. In reality, as long as the stands are comparatively young and vigorous, these attacks do not constitute a serious menace; only suppressed or otherwise defective trees succumb, but these repeated defoliations do cause appreciable retardation of growth, thereby postponing profitable utilization and causing ultimate loss in the total volume of the stands at maturity.

In 1948, the larch sawfly populations in the Maritimes remained at a very low level. In Newfoundland, all old infestations, except in the St. Georges District, were declining steadily; but several new outbreaks were reported from the northern peninsula, and light to moderate infestations occurred near Brig Bay and Main Brook. In Quebec, no appreciable damage was caused. In northern Ontario, heavy infestations were widespread throughout the Sioux Lookout, Fort Frances, Kenora, and Port Arthur districts. Somewhat lighter outbreaks are developing in Geraldton, Kapuskasing, Sault Ste. Marie, Cochrane, Temiskaming, and North Bay districts. Dry weather during the 1948 growing season aided the rapid defoliation of tamarack throughout eastern Manitoba by favouring a heavy emergence of sawfly adults. The extensive stands in the southeastern part of the province were most seriously damaged. Complete defoliation was observed at several points. In Saskatchewan, the sawfly was present in nearly all stands. Heavy attacks were found near Pelly, Sturgis, and Prince Albert, and in the Nisbet Provincial Forest. In other regions, the injury varied from light to moderate. In the northern part of the agricultural area of the Prairie Provinces, damage was more severe than in the south and a fairly general increase in sawfly populations was noticeable. An infestation was reported in the vicinity of Cold Lake, Alta. In the interior of British Columbia, there is a general decline in the intensity of outbreaks. Tamarack is a valuable tree, its wood being very durable in contact with the soil and particularly useful for fence posts, mine props, telephone poles, and railroad ties. Inasmuch as most of these uses require only comparatively small dimensions, it is advisable to manage larch stands on short rotation, thereby maintaining young, vigorous stands capable of resisting the periodic attacks of the sawfly. Additional protection is afforded by the liberation of insect parasites, of which numerous releases are made yearly by the Belleville Parasite Laboratory. Lately, experimental spraying of infested tamarack with a preparation of a fungous disease was tried in the Whiteshell, Riding Mountain, Pelly, and Nisbet areas. Although diseased larvae were recovered in check collections made after the spraying, more information is required before the control value of this fungus can be assessed.

The "dieback" of birch, a mysterious condition responsible for the wholesale destruction of large stands of white and yellow birch in Nova Scotia, New Brunswick, and Quebec has become a matter of great concern to the forest industry. Although several species of insects, especially the bronze birch borer, may contribute materially to the ultimate deterioration of the stands, it is generally felt that the primary cause of the injury must be some physical or biotic factor as yet unknown to science. The problem is under intensive inves-

tigation by several groups of entomologists, pathologists, and foresters in Canada and the United States. The Dominion Department of Agriculture is actively co-operating with the provincial forest services in the Maritimes, Quebec, and Ontario in all research projects related to this problem.

The lodgepole needle miner outbreak in the western national parks now covers an area of about 400 square miles. Up to the present, very few trees have been killed, but many trees in the mature stands near Lake Louise and Vermilion Pass have been so severely injured that their recovery is most unlikely. The effects of the outbreak were particularly evident in 1948, this being the last year of the two-year life-cycle of the insect. The entire area affected assumed a brownish tinge suggestive of a dying forest. Considerable significance is attached to the discovery of two new infestation centres a long distance from the main body of the outbreak, one 14 miles from Jasper and the other in the Livingstone district, near Maycroft, Alta. Should these centres become enlarged, the entire eastern slope of the Rocky Mountains may become involved; and should the forest cover of this region become materially depleted, an important source of water supply for the Prairie Provinces would in all probability be seriously impaired. Outbreaks of the leaf miner in the Western United States have usually been followed by bark-beetle infestations, and the combination has resulted in high tree mortality. Every effort will be made to forestall such an eventuality. In co-operation with the National Parks Service, the Division of Entomology has commenced an energetic campaign against the lodgepole needle miner. The possibilities of using parasites and disease organisms in combating the pest are being thoroughly explored. Experiments with DDT sprays distributed from aeroplanes were undertaken in 1948 and similar tests will be made in 1949-50.

The native elm bark beetle, which seems to be the principal carrier of Dutch elm disease in Canada, has continued to be the subject of experimentation in control with various chemicals. The Dutch elm disease spread into Ontario in 1948 and was discovered at Ottawa, and in Dundas, Grenville, Prescott, Stormont, Russell and Carleton counties. Various concentrations of DDT applied at different periods of the life-history of the beetles have given good results and warrant the belief that carefully applied sprays afford adequate protection for valuable shade trees in cities and parks. No satisfactory method of controlling the spread of the disease in wood-lots and forests is known at present. Further studies in chemical control will be pursued in 1949.

Insects affecting shade trees in shelterbelts, especially in the Prairie Provinces, are receiving due attention. The yellow-headed spruce sawfly, the pine leaf scale, the balsam fir sawfly, the spruce spider mite, the fall cankerworm, and the western willow leaf beetle were the most injurious species in 1948. A special plan for dealing with control problems has been developed in Saskatchewan. By mutual agreement, Dominion and Provincial agencies have defined their respective duties and responsibilities with a view to organizing more effective control programs on a co-operative basis.

The hemlock looper outbreaks in British Columbia have subsided, leaving in their wake considerable stands of valuable dead timber which should be salvaged in the shortest possible time. Officers of the Division of Entomology are actively participating in the planning of salvage operations to be undertaken by the lumber companies. The rather sudden development of bark-beetle outbreaks in the vicinity of some forests killed by the looper poses an additional problem.

The Department of Agriculture, realizing the importance of the forests to our national economy, is putting forth every possible effort in organizing an efficient service for the protection of the forest from insect depredations. Excellent laboratories, modern equipment, and adequately trained personnel

have been provided on an unprecedented scale. Forest insect problems, however, are vast and complicated and their final solution often requires time as well as the co-operation of all concerned.

## Systematic Entomology

Emphasis of work during the year has been directed along three major lines: (1) identification service on insects associated with economic problems of forestry and agriculture; (2) development of the National Collection, with research in special groups; and (3) a survey of the insects of arctic and sub-arctic Canada, with particular attention to the biting flies.

The Unit has continued to devote the greater portion of its time to the determination of significant material submitted by the officers of the various laboratories of the Division of Entomology, and the Division of Plant Protection, and by workers in the provincial entomological services, museums, and universities. At the same time, co-operation was continued with officers in the other Units of the Division in the solution of special problems. These include taxonomic studies of root maggots of garden crops, and of beetles concerned with "die-back" of birch, and an analysis of the insects associated with the crop rotation project at Saskatoon, with special emphasis on immature stages.

In the order Coleoptera, research has been directed towards problems of nomenclature in the Chrysomelidae (leaf-feeding beetles). In the Lepidoptera, research involving studies of genitalia in the family Phalaenidae (cutworms) was undertaken, and a start made toward a revision of the genus *Diarsia* Hbn. In the Diptera, progress has been made in revising certain genera of the Bombyliidae (bee flies), Lonchaeidae, Therevidae, and Tabanidae (horse flies, etc.). Considerable advances have been made in studies of arctic and sub-arctic Culicidae (mosquitoes) and Simuliidae (black flies). A specialist working at Saskatoon has made considerable progress on a study of immature stages of Diptera. Development of the hymenopterous collection has continued with emphasis on the various groups of parasitic wasps. In the family Ichneumonidae, material in two tribes has been arranged in accord with the most recent classification. The collections of Aulacidae and Gasteruptiidae have been revised by a specialist at Washington. At Ottawa, taxonomic studies have been continued in the Ichneumonidae, (particularly in the group Campoplegini), and in the sawflies, chalcids, and bees. An extensive revision of the major classification and nomenclature of the Chalcidoidea has been supplied chiefly by A. B. Gahan of the United States National Museum and has been incorporated into a catalogue, now nearly completed, for the representatives of this group in North America.

Important additions in several orders have been made to the National Collection. The northern survey has provided particularly valuable material in the Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Many donations, including type material, have been received from Canadian and American museums and universities. Field collections from British Columbia have contained valuable representatives of the Diptera and Hymenoptera. An identified collection of 14,000 fleas, containing specimens of most of the known North American species, has been transferred to the National Collection from the Livestock Insect Laboratory, Kamloops, B.C.

In 1948, the northern survey was expanded, parties undertaking extensive studies on biting flies and other insects at Goose Bay, Labrador; Knob Lake and Ft. Chimo, Quebec; Frobisher Bay, Baffin Island; Coral Harbour, Southampton Island; Saw Mill Bay, Great Bear Lake; Reindeer Depot, Mackenzie Delta; and along the Alaska Highway from Dawson Creek, B.C., to Snag, Yukon. This survey was made at the request of the Defence Research Board, Department of National Defence, and was part of a co-operative venture among the Division of Entomology, the Division of Botany and Plant Pathology, and

several Canadian universities. Valuable data were obtained on the distribution and biology of arctic and hudsonian mosquitoes, black flies, and horse and deer flies. In addition, the parties collected approximately 100,000 insects representing most of the orders; these have been incorporated into the Canadian National Collection.

## Biological Control of Insects

The distribution of beneficial insect parasites and predators was continued throughout the year in an effort to bring about a reduction in losses due to a number of destructive pests and to establish continuous control by biological means. Laboratories were established in Quebec and British Columbia to provide more effective local service and distribution of parasites throughout Canada. Through the service of the Commonwealth Bureau of Biological Control, beneficial species were obtained in some numbers from European and other countries. Transfer and distribution of established parasites and predators was continued and several new species were released. Field surveys and investigations were continued to determine the role and importance of various species in control, and research on fundamental problems was carried out at the Dominion Parasite Laboratory, Belleville, Ont. and by members of the laboratory staff working on special projects at universities in Canada and the United States.

Twenty-seven species of parasites and predators, 1,362,320 individuals in all, were released during the year in Canada in connection with the control of the following insect pests: grasshoppers and greenhouse whitefly in Alberta; apple mealybug and greenhouse whitefly in British Columbia; larch sawfly and greenhouse whitefly in Manitoba; spruce budworm, corn borer, and spruce sawfly in New Brunswick; spruce sawfly and greenhouse whitefly in Nova Scotia; spruce budworm, spruce sawflies, corn borer, greenhouse whitefly, grasshoppers, larch sawfly, and pine sawflies in Ontario; greenhouse whitefly in Prince Edward Island; spruce budworm, spruce sawfly, and greenhouse whitefly in Quebec; larch sawfly and greenhouse whitefly in Saskatchewan; spruce budworm and spruce sawfly in Newfoundland.

Efforts have been continued to establish more effective biological control of the spruce budworm in Eastern Canada. The collection of parasites in British Columbia was again carried out and eight species indigenous to the west coast were released at points in Ontario, Quebec, New Brunswick, and Newfoundland. A program of laboratory propagation and studies on the biology and habits of the parasites was carried forward, and the results obtained will aid greatly in their colonization in the forests. The development of improved breeding methods has made possible the release of larger numbers than in previous years. Through research on the use of artificial foods, a method has been developed for rearing the parasite *Pseudosarcophaga affinis* (Fall.) on a nutritive medium o liver and fish. This has made possible the production of large numbers of this parasite for release in 1949 and also provides an excellent means for carrying out fundamental research on the nutritive requirements of insect parasites generally. In co-operation with the Commonwealth Bureau of Biological Control, parasites of several species of budworms closely related to the spruce budworm were obtained from Europe during the summer of 1948. Colonies of three species from this source were liberated in carefully selected areas of budworm infestation in the Lac Seul district of northern Ontario, where their progress in establishment was studied. Other species not obtained in numbers sufficiently large for direct colonization were retained at the Belleville laboratory, where their biology was studied and colonies were propagated for liberation in 1949. Investigations in Europe were continued and everything possible was done to obtain additional natural enemies and establish permanent control of this destructive pest.

Collection of larch casebearer for the recolonization of two imported parasites in infested areas in other parts of Canada was limited by very low populations of the casebearer in Ontario. This was particularly true in the Millbridge area, where collections had been made during the past six years for redistribution. The increase of the parasite has been so great that in 1948 it was almost impossible to collect the casebearer within a radius of forty miles from the original liberation point. Collections of pupae of the larch casebearer have also been received from Europe. These are known to be rather heavily parasitized and the parasites will be reared for release in 1949.

From the rearing of larch sawfly cocoons collected in 1947, a few colonies of the imported parasites *Mesoleius aulicus* (Grav.) and *Bessa harveyi* (T.T.) were secured for release in Manitoba. Several large collections of larch sawfly larvae, parasitized by these species, were made in British Columbia in the fall of 1948 to provide additional stock for laboratory rearing and subsequent release in the infested areas of northern Ontario and Manitoba during 1949.

During the summer over 7,000 mated females of *Macrocentrus ancylivorus* Rohw. were reared in the laboratory and shipped for release against the pith cone worm, *Laspeyresia youngana* (Kft.), in Ontario. The liberations were made largely at Angus, Stittsville, and Bancroft, in areas where the seeds in the spruce cones were seriously injured.

Propagation and releases of parasites against a number of species of sawflies were carried out during the year. Colonies of four species of parasites were liberated in areas infested by sawflies attacking spruces and pines from Newfoundland to British Columbia. Releases of the parasite *Sturmia* sp. were made in the Western Provinces in an attempt to establish additional biological agents in the control of sawflies injurious to the trees of the western shelterbelts, as well as of other sawflies attacking alder and birch in certain areas of Ontario. Research was initiated to determine the influence of temperature and forest composition on the role of these parasites in the control of sawfly pests. It has been found that these factors play an important part in the relative distribution of both parasite and host, as well as in the ability of the parasites to locate the destructive insects.

Investigations on parasitism of grasshoppers in Western Canada have been continued and considerable data accumulated on yearly trends of abundance. These show definite relationships between parasite and grasshopper abundance and indicate the possible value of introduced and native parasites in the control of grasshoppers. Marked differences appear in the degree of parasitism in Manitoba and also in British Columbia. The more common parasites of grasshoppers were generally widespread throughout southern Saskatchewan in 1948. Two species of parasites obtained from Argentina were released in Alberta and one species in Ontario. Work in South America was continued through the winter of 1948-49 and additional parasites were obtained for release in 1949.

The introduced parasite *Collyria calcitrator* (Grav.) now appears to be well established on the European wheat stem sawfly, *Cephus pygmaeus* L., in central Ontario, where it was released in 1940. This parasite has increased in abundance very rapidly, and in some collections of overwintering sawfly larvae made in the fall of 1948, 35 to 40 per cent contained this parasite, making it a control factor of considerable importance.

The juniper scale, *Diaspis visci* (Schr.) has at times been injurious to trees in nurseries, parks, and private plantings. To establish natural factors of control on an infestation in the London and St. Thomas area of Ontario, an aphelinid parasite, *Aspidiotiphagus lounsburyi* B. & P., has been imported from Bermuda and released in specially selected stands.

Numerous requests were filled for the whitefly parasite, *Encarsia formosa* Gahan, from commercial growers, particularly those engaged in the production

of tomatoes, cucumbers, and other greenhouse crops. Shipments have been made to all parts of Canada and reports from the growers show that the parasite is very effective in the control of whitefly in greenhouses.

Studies directed toward the biological control of the carrot rust fly, *Psila rosae* (F.), and maggots attacking cabbage and turnip were carried out. Prior to the introduction of parasites from Europe, a survey was made to determine what biological factors are already present in the affected areas and their role in the control of the pest. A parasite, *Dacnusa gracilis* (Nees), which attacks the carrot rust fly in Europe, has been imported, and adult parasites are now available for release in certain areas in Ontario and British Columbia where the fly is causing severe damage to crops. Arrangements for the introduction of parasites of the maggots attacking cabbage and turnip are well advanced and it is expected that some species will be available for release in a short time.

Collections of the pea moth gathered in Eastern Canada and reared in Belleville indicate that the introduced parasite *Ascogaster quadridentatus* Wesm. is established in the Gaspe Peninsula, Prince Edward Island, and Nova Scotia. This is the first record of establishment of this parasite in Eastern Canada. It is expected that the abundance of the parasites will continue to increase as in British Columbia and in time help to prevent the recurrence of destructive outbreaks.

Further releases of European corn borer parasites introduced from Europe were made in New Brunswick. Additional shipments of corn borer parasites were also received from Switzerland. These, along with others now being propagated at the laboratory, will be released in the infested areas of New Brunswick and Ontario during 1949. Studies relating to the biology and habits of these parasites were carried out to obtain further knowledge of the relationship between the parasites and their hosts and the regional distribution of both.

Collections of the parasite *Allotropa utilis* Mues., previously transferred from Nova Scotia to the Kootenay Valley in British Columbia, were liberated on Vancouver Island in an area where the mealybug has recently appeared in damaging numbers. The parasites have now become established on the Island and have rapidly increased in numbers; it is hoped they will provide as satisfactory a means of control as they have in the Kootenay Valley.

The search for codling moth parasites in Europe, which was interrupted by the outbreak of war in 1939, was renewed in 1948, and it is expected that material will be available for release in Canada in 1949. Investigation of diseases of this insect was continued through the co-operation of Queen's University. The causative organism of an important primary disease was isolated and proved to be an undescribed species of bacteria. A method for propagation and distribution of this organism was developed, and its value under orchard conditions will be tested experimentally in 1949. Investigation of diseases affecting grasshoppers has also been carried out, and an organism with considerable promise of successful use has been isolated from South American material.

## Household and Medical Entomology

Biological and control studies of biting flies begun at Fort Churchill, Man., in 1947, as a joint project of the Division of Entomology on behalf of the Canadian Defence Research Board, and the U.S. Bureau of Entomology and Plant Quarantine on behalf of the Surgeon General, Department of the (U.S.) Army, were continued in 1948.

The number of pest species of mosquitoes (Culicinae) recorded at Churchill was increased to 13 in 1948 by the discovery of three additional species of *Aedes*. Three additional species of Chaoborinae brought the recorded total in this subfamily to four. In the larval stages the species of Chaoborinae are predacious on culicine larvae as well as other small aquatic life.

Studies of the adults showed that biting rates of certain species often remained high at high saturation deficiencies and at temperatures below 45°F. Two peaks of population were indicated: on June 29, representing the black-legged *Aedes*, and on July 8, representing these species plus the peak population of the banded-legged species. The peaks of alighting and biting occurred after the two peaks of abundance. The biting rate of the black-legged species was higher in comparison with the population and landing rate than that of the banded-legged species, suggesting a greater persistence in attack by the former.

The species association, seasonal development, emergence, abundance, and activity of black flies (Simuliidae) were further studied. Black fly abundance at Churchill was reduced in 1948 by deficient precipitation. The number of recorded species was increased in 1948 from 12 to 16.

Studies of *Simulium arcticum* Mall., the economically important species in the Saskatchewan River, indicated that this species overwinters in the egg stage, that the females lay their eggs over the surface of the water, and that the eggs sink to the bottom, apparently not hatching until the following spring.

In 1948, the species of bulldog, moose, and deer flies (tabanids) recorded at Churchill increased from 10 to 14. Observations on their feeding habits showed that a blood meal caused rapid development of eggs in the ovaries, the eggs numbering 600 to 700 in dissected specimens.

The 1947 studies at Churchill of the value of various insecticides in controlling the immature stages of black flies led to the development of an effective formulation and dosage, namely DDT in oil solution, at a concentration of 1 part of DDT to 10,000,000 parts by weight of water maintained for 15 minutes at the point of application. This treatment was successfully demonstrated on a large scale against *Simulium arcticum* Mall. in the South Saskatchewan River in May, 1948, and in the Lewes River at Whitehorse, Y.T., in July, 1948. The results were also confirmed by further tests at Churchill, and several other insecticides were investigated and showed definite promise.

Tests were made to ascertain possible harmful effects upon fish from the use of these insecticides. Exposures were made at various concentrations for 15 minutes using pike, northern suckers, lake trout, sticklebacks, arctic grayling fry, and spot-tailed minnows. The data indicate that DDT at the low dilutions required to control black fly larvae is not harmful to these species. Parathion was even less toxic than DDT. Benzene hexachloride was the most toxic but caused no mortality to grayling fry at dilutions greater than 1:2,000,000 of gamma-BHC. Sticklebacks and suckers were apparently not affected by even higher concentrations of this insecticide.

The experimental demonstration of black fly control on a large scale in the South Saskatchewan River was carried out in late May, 1948, as a joint project of the Division of Entomology, the University of Saskatchewan, the provincial Fisheries Branch, and the Suffield Experiment Station of the Defence Research Board. A 12 per cent (wt./vol.) solution of DDT in fuel oil, with Velsicol AR50 as the primary solvent, was applied to the river at Fish Creek, near Rosthern, by an R.C.A.F. C-47 aircraft, in successive swaths to produce a dosage of approximately 0·13 parts per million of DDT for a period of 36 minutes at the application site. This treatment almost eliminated the larvae of the cattle-infesting black fly, *Simulium arcticum* Mall., for a proved distance of 17 miles and a probable distance of 90 miles to the confluence of the river with the North Saskatchewan.

The elimination of black fly larvae in all the main breeding areas of the South Saskatchewan River may have prevented an outbreak of major proportions, because the larval populations were much heavier in 1948 than in 1947, when 211 head of livestock were killed by the black flies. The treatment is inexpensive and should be possible of application from bridges or boats and not necessarily by aeroplane. The treatment at the concentration used did not injure fish or seriously reduce the aquatic insect population in the river other than black fly larvae.

Applications of insecticides to snow and ice on potential breeding areas before the spring thaw are referred to as prehatching treatments. In 1948, tests on 1-acre plots at Churchill showed that DDT, TDE, and heptachlor were about equally effective as prehatching treatments, and all were superior to methoxychlor for the control of the prevalent species of *Aedes* in this region. At 0·25 lb. per acre, DDT and TDE gave 97 and 96 per cent control, and in additional tests DDT at 0·2 and 0·4 lb. per acre gave 97 and 99 per cent control, respectively.

Aeroplane prehatching control tests on ½-square-mile plots in forested areas with DDT-oil solutions gave 85 to 95 per cent control. In tests on open, eroded tundra and on mixed forest and open terrain, dosages of 0·09 to 0·35 lb. per acre gave satisfactory control in only one of four plots. The tests indicate that prehatching treatments may be used for control of arctic species of mosquitoes, but the requirements for control may differ greatly according to the type of terrain.

Comparative larvicide tests on small plots with hand equipment were made with DDT, parathion, TDE, methoxychlor, and heptachlor on arctic and subarctic species of *Aedes* mosquitoes. DDT and parathion in water-dispersible form gave nearly complete control of mature larvae at 0·05 lb. per acre. In tests with oil solutions, DDT with one exception killed more larvae at each dosage than the other materials, 0·1 to 0·2 lb. per acre causing 90 to 100 per cent mortality in 48 hours. Methoxychlor was about as effective as DDT at certain dosages, but was inferior at lower dosages. TDE and heptachlor were as effective as DDT at the lower dosages, but were inferior to DDT and methoxychlor at 0·1 and 0·2 lb. per acre. None of the materials, at the dosages tested, was effective against pupae.

Larval counts in a number of the 1947 prehatching test plots indicated some reduction in breeding one year after the treatments were applied. In small plots, maximum dosages of 1 lb. per acre of DDT and other insecticides appeared inadequate to give satisfactory control for two seasons. But in large, wooded areas that had been treated with approximately 0·5 to 0·25 lb. of DDT per acre by aeroplane in 1947, similar counts indicated a high degree of control. However, no residual effectiveness was evident in small plots treated with 0·1 to 0·2 lb. per acre of DDT, toxaphene, chlordane, or benzene hexachloride.

Thirty repellents which were known to have proved highly effective against mosquitoes at Orlando, Florida, in official United States military studies were tested for effectiveness when impregnated in stockings against *Aedes* mosquitoes at Churchill. Tests were made of the relative resistance of the repellents to rinsing, wearing, and outdoor aging, and outstanding ones were tested for effectiveness as skin treatments and when impregnated in uniforms against both mosquitoes and black flies (*Simulium*). In the rinsing tests, the outstanding repellent was hendecenoic acid. Hexyl mandelate and caprylic acid were only slightly less resistant to rinsing. None of the materials showed outstanding stability in the wearing tests. In the outdoor aging tests, none of the materials appeared capable of withstanding more than one week of exposure under outdoor conditions. Four materials survived a total of 87 hours of aging.

In the tests with uniforms, 10 of 14 treatments prevented black fly bites under the clothing when freshly impregnated, and 5 prevented black flies from landing. After 6 days of wear, black fly landings occurred on all treated uniforms, but 4 were still effective against biting. These repellents were hexyl mandelate, 2-(2-hyxyloxyethoxy) ethanol, dimethyl phthalate, and *alpha*-butoxy-*N*-cyclohexylacetamide. When impregnated in cotton T-shirts, all of the repellents provided protection against mosquitoes after 16 to 43 hours of wear, next to the skin, but none after 56 hours. Valid comparisons could not be made between the duplicate or different treatments because of the wide differences in the degree of wear and contamination in wearing by troops and scientific personnel.

Seventeen repellents were tested at full strength and 10 at one-quarter strength for effectiveness as skin treatments against mosquitoes and black flies. The most effective repellent was propyl *N*,*N*-dipropylsuccinamate, which gave an average protection time (to the first bite) against mosquitoes of 404 minutes at full strength and 138 minutes at one-quarter strength. The standard repellents, dimethyl phthalate, Rutgers 612, and 6-2-2 mixture, and the other materials gave protection for periods ranging from 296 to 368 minutes at full strength and from 33 to 125 minutes at one-quarter strength. In general, most of the repellents afforded longer protection against black flies than against mosquitoes. On the basis of these tests, none of the new repellents appeared sufficiently outstanding to warrant their adoption in place of the present standards.

Tests of the residual effectiveness against houseflies of various formulations of DDT on different surfaces have been continued at the Montreal Fumigation Laboratory in co-operation with the Division of Plant Protection. The four surfaces, masonite, planed pine, ten-test, and glass, which were sprayed with DDT in oil solution at the rate of 149 milligrams per square foot in August, 1945, lost a considerable amount of their insecticidal effect during 1948, and by March, 1949, were killing an average of only 75 per cent of adult houseflies used in the tests. Therefore, under laboratory conditions, these residues on these types of surfaces remained effective for approximately three years. Similar surfaces sprayed in 1946 with DDT in water suspension to give the same insecticidal residues, were still giving complete control of the houseflies in March, 1949.

The difference in aging of deposits of DDT water suspensions, under field and laboratory conditions, was indicated by comparative tests run during the summer of 1948 when duplicate surfaces were exposed in the laboratory and in a horse stable. After three months, the surfaces in the stable were brought in and compared with those held in the laboratory. The surfaces from the stable gave an average mortality of 98 per cent as compared with 100 per cent for the laboratory set. Corresponding figures for average time of 50 per cent knockdown of the flies were 38 and 20 minutes, respectively.

## Stored Product Insect Investigations

The milling companies have made widespread use of the improved methods of control of spider beetles, particularly in the Prairie Provinces, where these insects have been serious pests of flour and cereal products for a considerable period. During 1948, greatest use was made of DDT, usually in water suspension or emulsion form. In general, very satisfactory results were secured, and any unsatisfactory results arose in most cases through improper timing or faulty application.

The new methods of control were outlined in a pamphlet prepared by the Division of Entomology and distributed by the Canadian National Millers' Association early in 1948. This publication was supplemented by the general use of a coloured motion picture film outlining the biology and control of these pests.

Very little insect trouble has occurred in stored grain. Because of the rapid movement of grain, very little stock has remained on hand for more than very short periods. Close contact has been maintained with the trade to render assistance when necessary. A few infestations of granary weevils, rusty grain beetles, and grain mites were reported. Fumigation with carbon tetrachloride or chloropicrin yielded adequate control.

Piperonyl butoxide-pyrethrin mixture has shown considerable promise as a treatment of cotton sacks for the storage of flour. Sacks treated at the rate of 75 milligrams per square foot completely resisted insect entry for a period of over eight months. The tests are still in progress.

Residual sprays of piperonyl butoxide-pyrethrin mixture yielded partial control of insects in elevator boots in flour mills. Better results were secured by treatment of both leg and boot rather than by treatment of the boot alone. The treated areas were subject to re-invasion by insect migration.

Spot fumigants gave immediate control in elevator boots. Laboratory studies on fumigants of low vapour pressure indicated that control could be maintained for 50 to 100 days by materials of this type. Most of the materials in use at present as spot fumigants do not afford any protection against insect invasion after the treatment is complete.

Most of the spray-type milk powder plants in Ontario are now comparatively free from *Trogoderma versicolor* (Creutz.), one of the carpet beetles which has caused concern by infesting finished stock in storage. The use of vacuum cleaners and more efficient sanitation measures has been largely responsible for the improved conditions.

The use of a water-suspension type of DDT spray has greatly reduced the infestation of the tobacco moth in tobacco storage warehouses in Ontario. This type of control has been generally adopted by all the large storage warehouses in the area.

Close contact has been continued with the Board of Grain Commissioners on insect problems which arise in grain throughout the Dominion. Assistance in connection with insect problems was rendered to those operating flour mills, seed stores, grain elevators, and various types of food establishments.

## Livestock Insect Investigations

The major activities of the laboratories engaged in Livestock Insect Investigations in 1948-49 were characterized by biological studies on the insect and tick parasites of livestock. The new organic insecticides were given extensive study of their value for direct control as well as for use as repellents to prevent insect attack. In all of the experiments, the effect of the insecticide on the health of the animals and the suitability of their meat for human consumption form a definite part of the program.

The warble fly control campaign in the Prairie Provinces, carried out from the Lethbridge laboratory, was continued in co-operation with the provincial services, the Experimental Farms Service, and the Prairie Farm Rehabilitation Act Organization in all three provinces. Over one and three-quarter million cattle were treated. In some areas where the cattle formerly averaged 40 grubs per animal, the average now is less than 1 grub. Many farmers have purchased power sprayers for weed control, suitable for conversion for spraying cattle. This has greatly increased the number of sprayers available for warble fly control and consequently the number of cattle treated. Biological studies have shown that grubs which drop on the barn floor and are removed to the manure pile do not emerge as adult flies. When warble fly pupae are placed in the shade it may take from 1 to 3 weeks longer for the adult flies to emerge than when the pupae are exposed in the sun. Contrary to the findings in 1947, freshly emerged warble flies were actively interested in cows.

Studies on the biology of horse bots have shown that at least two species spend the first two instars of the larval life in the tongues or in pus pockets between the teeth of the horses before proceeding to the intestines, where they complete their development. In these two species, the movement from the tongue to the intestines is not made through the animal tissue. The second-stage larvae leave the tongue, are swallowed by the animal, and when they reach the intestines, attach themselves to the intestinal wall.

Spraying cattle with several of the new insecticides gave excellent control of horn flies. In some cases, the cattle were free of horn flies for the entire summer,

and made remarkable gains in weight in comparison with unsprayed cattle. The analysis of the data is not yet completed and it is impossible to say which insecticide was most effective.

Pure gamma isomer of benzene hexachloride, when given by mouth to rabbits, destroyed all of the paralysis ticks feeding on them. The rabbits showed no unfavourable symptoms of any kind though they were fed 50 milligrams of the insecticide per day for 3 successive days. Sprays containing 50 per cent gamma isomer BHC at the rate of 4 ounces to 1 gallon of water, kept cows free of ticks for 3 weeks.

### The Canadian Insect Pest Survey

Systematic collection of information on the occurrence, distribution, and economic importance of the insect pests in Canada was continued in 1948. Data obtained were used in supplementing the Canadian Insect Pest Record, and in the compilation of Volume 26 of the Canadian Insect Pest Review, consisting of nine numbers. One of these was made up of a list of the parasites liberated throughout the Dominion during the previous year. An annual summary of the more important insect infestations and occurrences was prepared for publication in the Annual Report of the Entomological Society of Ontario. The mailing list of the Review was augmented by several new names and was extended to include the libraries of all interested Canadian universities.

### Insecticides Registration and Advisory Service

The formulae, claims, and directions of several hundred proprietary insecticide preparations, submitted for registration for sale in Canada under the Pest Control Products Act, were reviewed by officers of the Division of Entomology during the year. This work ensures the maintenance of a high standard in the quality of the insecticides placed on the market for the use of the Canadian public. It also ensures that the public will be adequately warned and directed in the use of insecticides possessing such hazards to animal and plant life as inflammability, food contamination, and poisoning through skin absorption, inhalation, and contact. As well as protecting the interests of the public, the work greatly assists the insecticide industry in the development of formulations and the use of new chemicals. Duties in this field have increased and have become increasingly important in recent years as a result of the development of many new insecticides during the war and post-war periods. In addition to the review of applications, the work involves correspondence, personal interviews, and the preparation of publications on the nature and use of the new insecticides.

## DIVISION OF PLANT PROTECTION

This Division is responsible primarily for the administration of the Destructive Insect and Pest Act and the regulations formulated thereunder. The Act was passed in 1910, and at the present time twenty Foreign and ten Domestic regulations are in effect to prevent the introduction of injurious insects and diseases on plant material, and to control the movement within the country of established pests and plant diseases. One export regulation was passed in 1932, covering the export of apples to countries other than the United States and it was amended in 1947 to except Newfoundland.

The procedure governing the importation of nursery stock, which includes plants or portions of plants for propagation, except seeds and seed potatoes is briefly as follows:

1. A permit, procured from Ottawa, must be presented to Customs by importers, when obtaining release of consignments.

2. All shipments to Canada must be accompanied by a certificate of inspection, issued by an authorized inspector in the country of origin, declaring the contents to be apparently free from insect pests and plant diseases.
3. Such importations are subject to reinspection in Canada, and to treatment or destruction, if necessary.
4. Interceptions of insects and diseases, not readily identifiable by the inspection staff, are referred to specialists in the Divisions of Entomology, and Botany and Plant Pathology.
5. All importations must be routed through one of the established ports of importation in Canada.

Plant Inspection staffs are maintained at the following points: Halifax, N.S.; Saint John, N.B.; Quebec and Montreal, Que.; Ottawa, Toronto, Niagara Falls, London and Windsor, Ont.; Winnipeg, Man.; Estevan, Sask.; Vancouver and Victoria, B.C.

The certification of seed potatoes was started in the Maritime Provinces in 1915. Since that time the standards have been steadily raised and the work extended to every province in the Dominion. In 1938, this service became the responsibility of this Division and includes:

1. The establishment of standards governing production.
2. The supervision of production and shipment by inspection in the field, in storage, and at shipping point.
3. The development and supervision of tuber indexing and tuber units to improve and multiply foundation stock.
4. The issuance of official tags conforming to Canadian Certified seed potato standards.
5. Advice to growers on modern methods of seed potato production.

Certified Seed Potato Inspection staffs are stationed at Charlottetown, P.E.I.; Kentville, N.S.; Fredericton, N.B.; Ste. Anne de la Pocatiere, Que.; Ottawa, London, Guelph, and Barrie, Ont.; Winnipeg, Man.; Estevan, Sask.; Edmonton, Alta.; Vancouver and Victoria, B.C.

## Plant Inspection

The activities connected with Plant Inspection during the year ended March 31, 1949, are summarized as follows:

*Imports of Plants.*—There were 30,932,182 bulbs and 25,405,370 plants, or a grand total of 56,337,552 plant units valued at $1,977,701, imported from 30 different countries in 82,044 containers, under 9,701 standard and 706 emergency permits, requiring 10,133 separate inspections, of which 3,233 dealt with parcel post importations involving 464,817 plants, bulbs, etc.

Two hundred and thirty-three importations of plant material, comprising 9,921 plants and 25·5 pounds of seed potatoes were refused entry because of infractions of regulations under the Destructive Insect and Pest Act.

*Inspection of Passengers' Baggage.*—This activity applies mainly to ocean ports, where a total of 2,835 passenger and freight ships was attended. Twenty-four trains and nine automobiles were also attended. As a result, 156 passengers were found to have 3,150 plants and 1,479 pounds of plant products in their possession. Two of the plants and 216 pounds of potatoes were refused entry under the Regulations and 915 pounds of fruit for lack of proper certification. The inspection staff works very closely with the Customs officers in carrying out these duties.

At Windsor and Niagara Falls similar co-operation is provided to Customs officers and during the year 178 shipments of nursery stock and 46 of plant products were refused entry. These included 1,146 plants and 712 ears of green corn. At border points where an inspector of the Division of Plant Protection is not available, regulations of the Destructive Insect and Pest Act are administered by Customs officers. Plants being imported at such points, which are not prohibited by regulation, may be diverted through an authorized port of importation for inspection if the owner so desires.

Due to the heavy tourist traffic, Customs authorities requested that an inspector be stationed at the following border points to administer Regulations of the Department during the busy season: Sarnia, Ont.; and Pacific Highway, B.C., and a third inspector visited Ivy Lea, Ont. at intervals. As a result, 146 motorists were found to have 626 plants, 160 ears of green corn and 386 pounds of fruit in their possession. Twenty-five plants and the 160 ears of corn were refused entry under the regulations and the 386 pounds of fruit for lack of certification.

*Introduction of Live Insects, etc.*—During the year, 37 permits were issued under Regulation No. 21 (Foreign) covering the importation for investigational and experimental purposes of various stages of insects, insect parasites, bacterial or fungus cultures, and plant diseases.

*Imports of Plant Products.*—There were 939 inspections made of plant products from 36 countries involving 1,332,319 containers. In 195 instances shipments were refused entry. These involved 872 ears of green corn, 1,563 pounds of fresh fruit and 216 pounds of potatoes.

*Exports of Plants and Plant Products.*—Nursery stock was inspected and certified for export to 35 countries, totalling: 352,537 plants, 7,816,286 bulbs, corms and cormels; and 10,219 pounds of tree and miscellaneous seed. Plant products, certified as a requirement of the importing country, were exported to 28 countries, and consisted of: 6,895,015 pounds of table stock potatoes, 1,697 pounds and 160 ears of seed corn, 95,237 pounds of vegetable and cereal seed, 200,000 pounds of seed oats, 1,212 pounds of pears, 50,000 pounds of frozen fruit, 101 pounds of grass seed, 29,931 Christmas trees and 72,087 pounds of vegetables.

*Interceptions.*—The number of interceptions of insects and diseases taken on imported plants and plant products was 1,162. Among these, soft rot of hyacinths and the giant African snail were new to Canada. Other interceptions of interest were larvae of the gold tail moth, a gypsy moth egg mass and various stages of the durra stem borer and European corn borer.

*Protection of Imported Food Products.*—The inspection service continued to check carefully a large range of edible plant products. Importations from various countries of the world have been found infested with insects, and frequently fumigation or cold storage treatment has been required.

*Stored Products Inspections and Investigations.*—Efforts were continued to safeguard food products from serious insect damage and consequent loss through the inspection of ships carrying grain and cereal products overseas. During the past shipping season, 1,126 vessels were examined at seaboard ports and 165 of these required treatment by fumigation or cleaning; 110 vessels were also examined at the Lakehead, previous to taking on cargoes of grain for winter storage and 46 required cleaning.

*Montreal Fumigation and Research Laboratory.*—During the year activities included the direction of operations connected with the fumigation, in railway box cars, of many tons of broom corn from Italy, Hungary and Argentina for the control of corn and stem borers, the treatment of large shipments of peanuts from

India and Algeria infested with stored products insects, the treatment of Californian potatoes, walnuts, coffee beans, cocoa beans, seed corn and second-hand bags; and the commercial fumigation of such infected products as walnuts, mixed seeds and second-hand bags. Experiments were carried on to find a more efficient method of fumigating the empty holds of steamers, low temperature fumigation, the fumigation of gladiolus corms, and the residual effect of DDT on houseflies.

A new detector for methyl bromide was also developed in co-operation with the Department of National Health and Welfare.

## Field Projects

The main field projects carried on in 1948 with the object of determining the distribution and control of destructive insect pests and plant diseases were as follows:—

*Apple Maggot.*—This insect is a native of North America and occurs in all fruit-growing areas of Ontario, Quebec and the Maritime Provinces. It is not known to be established in Europe and on this account special precautionary measures have been undertaken each year by co-operating government agencies to safeguard and maintain the apple export trade. This Division co-operated in Nova Scotia with provincial authorities in the enforcement of control measures and assisted in the pre-harvest inspection of the fruit. The Division also assisted with the pre-harvest inspection of the fruit in certain orchards in New Brunswick, Quebec and Ontario, the owners of which had followed the control practices as stipulated in the amendment to Regulation No. 1 (Export) which became effective June 17, 1947. Because of the exchange situation, no apples from the 1948 crop were exported to Great Britain with the exception of a small number of gift parcels.

*Dutch Elm Disease.*—This destructive disease of elm, first observed in Holland in 1919, and in the United States in 1930, was found in the province of Quebec in 1944.

Regulation No. 17 (Foreign) of the Destructive Insect and Pest Act was passed in 1928 prohibiting the importation of elms from Europe and amended in 1934 to prohibit the importations of all species of elms from all countries. Regulation No. 12 (Domestic) was passed in 1945 and amended in 1947 to control the movement of elms and elm products from areas found infected in Canada. Surveys have been conducted annually by this Division, with provincial agencies co-operating in Quebec and Ontario, and in 1948 the disease was found for the first time in eastern Ontario. Since the disease was discovered in 1944, infected elms have been found in 39 counties in Quebec and in 6 in Ontario. The Division of Plant Protection assumed the responsibility of supervising the removal of infected trees following the 1945 survey and this policy has been continued. So far it has been possible to have trees removed by property owners, public utility companies, and the municipalities concerned, thus relieving the Dominion and Provincial Departments of the expense. All infected trees located from 1944 through 1947 were removed by the end of May, 1948, except 500 in a large wood-lot in Richelieu county where it was not practicable to have the work performed. During the 1948 survey season 2,581 infected trees were located in the province of Quebec and at the end of March, 1949, the number of trees cut was 1,592 with the expectation that the balance would be cut by the end of May. In Ontario, 14 infected trees were located, and immediately after confirmation they were cut by the owners and the wood and stumps sprayed by Divisional personnel.

*Japanese Beetle.*—This insect, a native of Japan, was first discovered on this continent in 1916 in the State of New Jersey. Since 1927, special precautions have been taken by this Division to prevent its introduction and establishment

in Canada, but in spite of all efforts the first established infestation was discovered at Niagara Falls, in 1940, and the second at Windsor, Ont., in 1941.

Trapping has been carried on at various points throughout Eastern Canada since 1935. The Ontario Department of Agriculture has assisted with trapping operations by providing trap attendants each year and the Nova Scotia Department of Agriculture has co-operated in a similar manner. From 1939 to 1948 inclusive, 4,593 beetles have been captured in traps and collected by scouting in Ontario, Quebec and Nova Scotia.

From 1941 to 1946 inclusive, 284 acres of soil were treated with arsenate of lead at several points in Ontario and 4·5 acres at Halifax, N.S. The amount of arsenate of lead required to treat this acreage was 72·5 tons.

In addition to the provincial departments already mentioned, co-operation in connection with Japanese beetle work has been received from the Ontario Agricultural College, park and civic authorities where soil treatment was applied, the Division of Entomology of this Department and the Canadian National Railways.

The question of placing a quarantine on infested areas in Ontario has been discussed at various times but it does not appear advisable or necessary to take such action at present. Known outbreaks have been treated where such action appeared advisable, and careful consideration will be given to new outbreaks if, and when, they are located.

*Oriental Fruit Moth.*—This insect, a native of Japan, has been known to occur in eastern North America for over thirty years where it has caused enormous damage to peaches and other soft fruits. During the last few years, it has spread to the Pacific coast states and a few specimens were trapped in Washington in 1945. Fruit growers organizations and government agencies in British Columbia were greatly concerned about possible spread into that province and it was decided to carry on surveys in the peach growing area of the Okanagan Valley. The United States Department of Agriculture co-operated with this Division by furnishing 400 specially-designed traps and certain bait materials. These traps have been placed in peach orchards in southern British Columbia and examined regularly by officers of this Division during an eight-week period in midsummer in 1946, 1947 and 1948 but no specimens of the insect have been captured. Due to the discovery of an apparent infestation of this pest in Washington in 1948, it is proposed to conduct the survey in British Columbia again this year.

*Grader Inspection of Fruit, British Columbia.*—This work has been carried on from 1944 to 1948, inclusive, in the packing houses in the southern half of the Okanagan Valley under the supervision of this Division. The British Columbia Department of Agriculture and B.C. Tree Fruits, Ltd., have co-operated by supplying funds to cover a portion of the wages paid to the inspectors. The object of the survey is to locate infestations of the San Jose and European fruit scale in order that no fruit from infested orchards would be offered for export to countries demanding a certificate of freedom from scale insects. Results of the annual surveys have been made available to the co-operating agencies with recommendations that efforts be made to control the infestations. The 1948 survey indicated good progress had been made in several areas.

*European Earwig Investigations.*—Trapping for this insect was carried on in Toronto during the summer of 1948 in the area surrounding the outbreak discovered in 1946 and the results indicated no spread of the pest. Observations were continued, by the Montreal staff, on the infestation in the Westmount district and the outbreak still appears to be confined to a small area.

*Sugar Beet Nematode Survey, Ontario.*—The sugar beet nematode was discovered several years ago in the beet-growing area east of Sarnia, in Lambton county. In order to determine if the pest had spread outside the original area

which had been placed under a provincial quarantine, this Division assumed the responsibility of supervising a survey during the shipping season of 1948. With the co-operation of the Ontario Department of Agriculture, inspectors were stationed at a number of beet-loading points in several counties of southwestern Ontario during October and November. No appreciable spread occurred within the quarantined area but nematodes were discovered on one farm located southwest of Chatham.

*Gypsy Moth Trapping, New Brunswick.*—In an effort to determine if the gypsy moth was spreading into southwestern New Brunswick from heavily-infested areas in south central Maine, the United States Department of Agriculture provided this Division with 100 specially-designed traps for use in the St. Stephen–St. Andrews area. The traps were placed and examined regularly during the flight period of the moth but no specimens were captured.

## Seed Potato Certification

The total acreage of potatoes entered for certification throughout Canada in 1948 amounted to over 70,000 representing an increase of approximately 1,100 acres. This is the greatest acreage ever entered. Slightly over 80 per cent of the acreage entered passed field inspection in the three classes. Almost 5½ million bushels of Foundation and Foundation A seed were produced out of a total of 12¾ million bushels which passed in the three classes. This total production is a million bushels more than were produced in 1947 and is the highest on record.

Tuber indexing was continued in greenhouses at several points to aid growers in the selection of disease-free seed for tuber unit planting.

In 1948, 8,824 growers entered, for inspection, 15,635 fields, comprising 70,561 acres, of which 57,392 acres passed. This is highest on record. The acreage passed of the main varieties were—Katahdin, 21,904; Irish Cobbler, 11,701; Green Mountain, 11,577 and Sebago, 6,940. This shows a great increase for Katahdin and a decrease in Irish Cobbler and Green Mountain over the previous year. There was an increase of approximately 1,000 acres of Sebago over that passed in 1947.

*Shipments.*—Shipments of the 1947 crop totalled 6,749,762 bushels, of which 4,268,454 bushels were exported and 2,481,308 sold in Canadian markets. The principal importing countries were: United States—2,327,094 bushels; Argentina—1,166,270; Cuba—325,692; Uruguay—204,019; Venezuela—84,693; Palestine—63,640; British West Indies—30,691 and Mexico—19,278 bushels. The main exporting provinces were Prince Edward Island and New Brunswick with 2,082,224 and 1,897,414 bushels respectively.

Shipments from the 1948 crop to March 31, 1949, totalled 6,670,095 bushels, of which 6,070,332 bushels were exported and 599,763 bushels were shipped to domestic markets. The principal foreign markets for 1948 crop were: United States—5,114,809 bushels; Cuba—354,374; Uruguay—263,123; Venezuela—119,691; Argentina—86,089; and South Africa—54,840 bushels.

*Foundation Seed.*—The production of Foundation seed showed a slight decrease in 1948 over that produced in 1947. In 1948 the crop from 4,482 acres produced 919,450 bushels compared with 4,889 acres yielding 994,900 bushels in 1947.

*Foundation A Seed.*—The production of Foundation A was approximately the same in 1948 as was produced in 1947. In 1948, 22,196 acres produced 4,480,800 bushels compared with 22,175 acres yielding 4,342,000 bushels in 1947.

*Certified Seed.*—The production of certified seed in 1948 showed an increase of approximately 4,000 acres producing a million bushels more than the previous year.

*Production.*—Total production of graded stock in 1948 has been estimated at 12¾ million bushels, of which 919,450 bushels were eligible for Foundation tags, 4,480,800 bushels for Foundation A tags and 7,312,050 bushels for certified tags.

*Tuber Indexing.*—Tuber indexing was carried on during the winter in Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Manitoba and Alberta. A total of over 62,000 tubers were indexed and over 57,000 returned to the growers for tuber unit planting.

*The Potato-Rot Nematode.*—(*Ditylenchus destructor Thorne*).—This pest was first found in Canada in Queens county, Prince Edward Island, in 1945 by inspectors of this Division. Since that time, the three areas where the nematode has been discovered (York, Uigg and Bideford) have been under quarantine, which quarantine has been enforced largely by inspectors of this Division. In these areas, certified seed potatoes cannot be produced and table stock potatoes produced only in fields where nematodes have not been found. However, all table potatoes produced in these areas must be held until November 15 of each year and inspected for nematodes before they can be moved off the farm. In 1948 this pest was found in ten fields in the Bideford area and one field in the York area. In addition, the pest was found in one field adjoining the Bideford area.

## International Plant Legislation

Plant regulations maintained by foreign countries are studied and summarized as affecting exports of plants and plant products from Canada. Copies of the resultant instructions are distributed to staffs throughout the Dominion for their information and guidance in certifying such shipments.

With the rapid advancement of air traffic, the air lines operating in North America took action in 1947 to establish a Canada-United States Air Facilitation Committee. In addition to officials of air transport companies, the Committee is composed of representatives of Customs, Immigration, Post Office, Health and Agriculture. The Committee held one formal meeting during the year in Washington, D.C. The officer of the Division of Plant Protection appointed by the Department to represent the various units concerned with the movement of agricultural commodities, livestock, etc., by air, attended the meeting.

## Destructive Insect and Pest Act Advisory Board

This board was constituted by Order in Council P.C. 840, April 21, 1922, and re-constituted by Order in Council P.C. 7095, September 15, 1944. The Chief of the Division of Plant Protection acts as Secretary.

The duties of the Board are to consider and recommend such amendments to the Destructive Insect and Pest Act and Regulations thereunder as it may deem necessary in the public interest, and advise the Division of Plant Protection, as required in the formulation of policies with respect to the administration thereof.

During the year six meetings were held. Among the more important matters considered were: the establishment of a bulb inspection service in British Columbia; the proposed revision of U.S. Quarantine No. 37, as applying to Canada; the introduction of insects and plant diseases required for entomological

and plant pathological research and the revision of several Regulations under the Act to be included in the consolidation being prepared. One new Regulation, Number 13 Domestic governing the production and sale of narcissus, tulip, hyacinth and iris bulbs in British Columbia was passed by Order in Council P.C. 2146, May 13, 1948. No other changes were effected during the year.

### Co-operation With Other Organizations

During the year the Division of Plant Protection received co-operation and collaboration from the following:

The Divisions of Entomology, Botany and Plant Pathology, Fruit and Vegetable, Horticulture, and Health of Animals, of the Dominion Department of Agriculture; the Dominion Department of National Revenue, (Customs Division); the Dominion Department of Trade and Commerce; the Quebec Department of Lands and Forests; the Provincial Departments of Agriculture in the various provinces, and the United States Bureau of Entomology and Plant Quarantine.

# DIRECTORY OF SCIENCE SERVICE OFFICES AND LABORATORIES

Director, Science Service—Science Service Bldg., Ottawa

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### Newfoundland

| | |
|---|---|
| Plant Inspection Office | 123 Water Street, St. Johns |
| Dominion Entomological Laboratory (Field Crop Insects) | 123 Water Street, St. Johns |

### Nova Scotia

| | |
|---|---|
| Dominion Laboratory of Plant Pathology (Fruit and Vegetable Diseases) | Kentville |
| Dominion Agricultural Chemistry Laboratory | Kentville |
| Dominion Entomological Laboratory (Fruit and Vegetable Insects) | Annapolis Royal |
| Plant Inspection | Dominion Public Bldg., Halifax |
| Seed Potato Certification | Experimental Station, Kentville |

### Prince Edward Island

| | |
|---|---|
| Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases) | Charlottetown |
| Dominion Entomological Laboratory (Field Crop and Vegetable Insects) | Charlottetown |
| Seed Potato Certification | Laboratory of Plant Pathology, Charlottetown |

### New Brunswick

| | |
|---|---|
| Dominion Animal Pathology Laboratory | Sackville |
| Dominion Laboratory of Plant Pathology (Potato Viruses; Field Crop, Fruit, and Vegetable Diseases) | Fredericton |
| Dominion Laboratory of Forest Pathology | Fredericton |
| Dominion Entomological Laboratory (Forest, Field Crop, Vegetable and Fruit Insects) | Fredericton |
| Plant Inspection | Customs Bldg., Saint John |
| Seed Potato Certification | Customs Bldg., Fredericton |

### Quebec

| | |
|---|---|
| Division of Animal Pathology (Administration, Animal Pathology, Poultry Pathology, Biological Products, Parasitology, and Laboratory Services) | Hull |
| Animal Parasitology | Institute of Parasitology Macdonald College |
| Dominion Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases) | Ste. Anne de la Pocatiere |
| Dominion Laboratory of Plant Pathology (Fruit and Vegetable Diseases) | St. Jean |
| Dominion Entomological Laboratory (Fruit Insects) | Hemmingford |
| Dominion Entomological Laboratory (Fruit and Vegetable Insects) | St. Jean |
| Seed Potato Certification | P.O. Building Ste. Anne de la Pocatiere |
| Plant Inspection | 3 Buade St., Quebec |
| Dominion Entomological Laboratory (Biological Control) | Quebec |
| Plant Inspection | 105 McGill St., Montreal |
| Fumigation Station | 785 Mill St., Montreal |
| Dominion Entomological Laboratory (Vegetable Insects) | Ste. Anne de la Pocatiere |

### Ontario

| | |
|---|---|
| Poultry Pathology Laboratory | Science Service Bldg., Ottawa |
| Division of Bacteriology and Dairy Research (Administration, Dairy Research, Food Microbiology, Soil Microbiology, and General and Analytical Bacteriology) | Science Service Bldg., Ottawa |
| Division of Botany and Plant Pathology (Administration, Agricultural Botany, Systematic Botany, Dominion, Arboretum, Herbarium, Mycology, Forest Pathology, Fruit and Vegetable Diseases, Seed-Borne Diseases, and Plant Physiology) | Science Service Bldg., Ottawa |
| Dominion Laboratory of Forest Pathology | 144 Front St., Toronto |
| Dominion Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases) | St. Catharines |
| Dominion Laboratory of Plant Pathology (Special Crop and Vegetable Diseases) | Harrow |
| Division of Chemistry (Administration, Food Chemistry, Soil Chemistry, Animal Nutrition, Plant Chemistry, Vitamin Assays) | Science Service Bldg., Ottawa |
| Division of Entomology (Administration, Field Crop Insects, Forest Insects, Systematic Entomology and National Insect Collection, Stored Product Insects, and Insects of Household and Man) | Science Service Bldg., Ottawa |
| Dominion Entomological Laboratory (Forest Insects) | Sault Ste. Marie |
| Dominion Parasite Laboratory (Propagation and Liberation of Parasites of Destructive Insects) | Belleville |
| (The Commonwealth Bureau of Biological Control of Farnham Royal, England, operated under the Commonwealth Agricultural Bureau, has been transferred to Ottawa.) | |
| Dominion Entomological Laboratory (Fruit Insects) | Vineland Station |
| Dominion Entomological Laboratory (Field Crop and Vegetable Insects) | Chatham |
| Dominion Entomological Laboratory (Fruit Insects) | Simcoe |
| Plant Protection Division (Administration, Plant Inspection, and Seed Potato Certification) | Science Service Bldg., Ottawa |
| Plant Inspection | 21 Lombard St., Toronto |
| Seed Potato Certification | Ontario Agricultural College, Guelph |
| Plant Inspection | Federal Bldg., Niagara Falls |
| Plant Inspection and Seed Potato Certification | Dominion Public Bldg., London |
| Plant Inspection | Canada Building Windsor |
| Seed Potato Certification | Barrie |

### Manitoba

| | |
|---|---|
| Dominion Laboratory of Plant Pathology (Field Crop, Vegetable, and Seed-Borne Diseases) | Winnipeg |
| Dominion Entomological Laboratory (Forest Insects) | Winnipeg |
| Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects) | Brandon |
| Dominion Entomological Laboratory (Stored Product Insects) | Dom. Public Bldg. Winnipeg |
| Plant Inspection and Seed Potato Certification | Dom. Public Bldg., Winnipeg |

### Saskatchewan

| | |
|---|---|
| Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases) | Saskatoon |
| Dominion Laboratory of Forest Pathology | University of Sask., Saskatoon |
| Dominion Entomological Laboratory (Field Crop and Vegetable Insects) | Saskatoon |
| Dominion Entomological Laboratory (Forest and Shade Tree Insects) | Indian Head |
| Plant Inspection and Seed Potato Certification | P.O. Bldg., Estevan |

### Alberta

| | |
|---|---|
| Dominion Entomological Laboratory (Forest Insects) | Calgary |
| Dominion Veterinary Research Station | Lethbridge |
| Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases) | Edmonton |
| Science Service Laboratory | Lethbridge |
| Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases) | Lethbridge |
| Plant Inspection | Lethbridge |
| Seed Potato Certification | 207 Northern Building, Edmonton |
| Dominion Entomological Laboratory (Field Crop, Vegetable and Livestock Insects) | Lethbridge |
| Plant Inspection | Post Office Building, Lethbridge |

### British Columbia

| | |
|---|---|
| Dominion Animal Pathology Laboratory | University of British Columbia, Vancouver |
| Dominion Laboratory of Plant Pathology (Fruit and Vegetable Diseases) | Summerland |
| Dominion Laboratory of Plant Pathology (Fruit, Ornamental Plant Vegetable and Seed-Borne Diseases) | Saanichton |
| Dominion Laboratory of Plant Pathology (Vegetable and Fruit Diseases) | University of British Columbia, Vancouver |
| Dominion Laboratory of Forest Pathology | Belmont Bldg., Victoria |
| Dominion Agricultural Chemistry Laboratory | Saanichton |
| Dominion Agricultural Chemistry Laboratory | Summerland |
| Dominion Entomological Laboratory (Fruit Insects) | Summerland |
| Dominion Entomological Laboratory (Forest Insects) | Vernon |
| Dominion Entomological Laboratory (Biological Control) | University of British Columbia, Vancouver |
| Dominion Entomological Laboratory (Live Stock Insects) | Kamloops |
| Dominion Entomological Laboratory (Field Crop and Vegetable Insects | Kamloops |
| Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects) | Agassiz |
| Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects) | Parliament Bldg., Victoria |
| Dominion Entomological Laboratory (Forest Insects) | Central Bldg., Victoria |
| Plant Inspection and Seed Potato Certification | Federal Bldg., Vancouver |
| Plant Inspection and Seed Potato Certification | Parliament Bldg., Victoria |
| Bacteriological Laboratory | Summerland |

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